FUNDAMENTAL TECHNIQUES OF PLASTIC SURGERY AND THEIR SURGICAL APPLICATIONS

FUNDAMENTAL TECHNIQUES OF PLASTIC SURGERY

AND THEIR SURGICAL APPLICATIONS

BY

IAN A McGREGOR
M B F R C S (Eng) F R F P S (Glas)
Consultant Plastic Surgeon Glasgow Royal Infirmary
Lately Consultant Surgeon Casualty Department
Glasgow Royal Infirmary

FOREWORD BY

C F W ILLINGWORTH
C B E M D Ch M F R C S (Ed) F R F P S (Glas)
Hon F A C S Hon F R C S (Eng)
Regius Professor of Surgery University of Glasgow



E & S LIVINGSTONE LTD
EDINBURGH AND LONDON
1960

FOREWORD

LIKE other surgical specialties Plastic Surgery originated through the efforts of a small group of enthusiasts who by utilising a particular refinement of technique soon raised the standards of surgical craftsmanship within a narrow field to a high pitch of efficiency

Then came the war and the techniques primarily evolved for hiding facial blemishes and correcting visible deformities were applied with immense success to the treatment of wounds in general Since then as a natural sequel plastic surgeons have widened still further their range of interests notably in casualty work in hand injuries and in burns In doing so they have implicitly ceased to regard themselves as a class apart exclusive authorities in a chosen field but rather as expert advisers and helpful collaborators in a wide range of surgery

Mr McGregor is emphatically of this latter class trained in the Glasgow School of Plastic Surgery broadened in experience by the responsibility of a busy casualty department and with a particular interest in the surgery of the hand His book reflects these interests and this experience being designed not for specialists but for all those who are concerned with the healing of wounds Its approach is essentially practical dealing as it does with the choice of incisions with stitchcraft avoidance of ugly scars, methods of skin grafting and similar matters and with their application to casualty surgery orthopaedics and general surgery It will assuredly receive a warm welcome

Glasgow 1960 C F W ILLINGWORTH

PREFACE

PLASTIC surgical methods are being used increasingly often by surgeons who have received no formal training in plastic surgery and who are looking for guidance on the basic techniques Advanced textbooks of plastic surgery are apt to pass over those elementary but nonetheless fundamental methods while the sections on plastic surgery in textbooks of surgery describe its scope and results without giving enough detail of actual technique to be of practical use This book I hope may help to fill the gap

The first part describes the basic techniques of plastic surgery in detail and the second considers their application to the situations which surgeons in other specialties are likely to encounter A difficulty in the second part has been that of deciding what material to include and what to leave out The deciding factor generally has been to include such topics and techniques as it was felt a surgeon in the particular field might reasonably wish to deal with himself without necessarily referring the patient to a plastic surgeon

The book makes no attempt to describe all possible methods of repair and reconstruction To include a multiplicity of methods in a book of this nature would merely confuse and I have preferred instead to describe those methods which I have found work best in practice

In discussing the basic techniques I have tried to stress the difficulties of each and to describe the complications, how they can be avoided and how to cope with them when they do occur I have endeavoured too, to bring out the principles of the various methods in the hope that an understanding of these principles may weld the technical details into a coherent, rational pattern and prevent them from being a mere jumble of empirical instructions

A difficult decision has been whether or not to use the eponyms in which plastic surgery abounds Eponyms are an essential part of everyday surgical shorthand and they recall men who have stood as signposts along the way of an advancing specialty But often they lack precise meaning and they are liable to cause confusion, firstly because they sometimes have different meanings in different countries, secondly because they are frequently used loosely so that in some instances a name has even come to be applied to a procedure different from that

described by its owner The Thiersch graft is an example of this latter category being nowadays applied to a graft of quite different thickness from that originally described by Thiersch For these reasons I have regretfully avoided eponyms altogether

References have purposely not been introduced into the text. Instead I have listed a few papers and monographs at the end of each chapter under suitable subject headings to provide a starting point for anyone wishing to pursue a particular subject further

I must acknowledge my debt to many who have helped me in preparing this book To Professor C F W Illingworth who encouraged me at the outset in its writing and Mr J S Tough who was responsible for my training in Plastic Surgery and gave me free access to the photographic records of the Unit I am deeply grateful I am greatly in the debt of Mr Douglas R K Reid for his constructive criticism of the text and for the pains he has taken to make it as lucid as possible without sacrificing brevity in the process To Professor Roland Barnes and Dr J C J Ives who read and criticised parts of the text I express my thanks

The illustrations are all important in a book largely concerned with surgical techniques Mr Robin Callander made all the drawings and I find it difficult to convey fully the care and trouble he has taken to portray visually what I wished to express Any usefulness which the book may have is due in no small way to his illustrations The photographs are the work of Mr T Meikle and Mr R. Macgregor of the Plastic Surgery Units at Ballochmyle Hospital and Glasgow Royal Infirmary Mr R McLean Department of Medical Illustration Western Infirmary Mr P Kelly Photographic Department and Mr E Towler Department of Surgery Glasgow Royal Infirmary For the care and trouble which each has taken I am most grateful I am also indebted to Messrs Chas F Thackray for permission to use illustrations of their instruments

The typing and retyping of the manuscript was carried out with patience and good humour by Mrs. A M Drummond

I should like lastly to record my thanks to Mr Charles Macmillan and Mr James Parker of Messrs E. and S Livingstone for the advice and help which they have given me throughout

IAN A. MCGREGOR.

Glasgow 1960

PREFACE

PLASTIC surgical methods are being used increasingly often by surgeons who have received no formal training in plastic surgery and who are looking for guidance on the basic techniques Advanced textbooks of plastic surgery are apt to pass over those elementary but nonetheless fundamental methods while the sections on plastic surgery in textbooks of surgery describe its scope and results without giving enough detail of actual technique to be of practical use This book I hope may help to fill the gap

The first part describes the basic techniques of plastic surgery in detail and the second considers their application to the situations which surgeons in other specialties are likely to encounter A difficulty in the second part has been that of deciding what material to include and what to leave out The deciding factor generally has been to include such topics and techniques as it was felt a surgeon in the particular field might reasonably wish to deal with himself without necessarily referring the patient to a plastic surgeon

The book makes no attempt to describe all possible methods of repair and reconstruction To include a multiplicity of methods in a book of this nature would merely confuse and I have preferred instead to describe those methods which I have found work best in practice

In discussing the basic techniques I have tried to stress the difficulties of each and to describe the complications, how they can be avoided and how to cope with them when they do occur I have endeavoured too, to bring out the principles of the various methods in the hope that an understanding of these principles may weld the technical details into a coherent, rational pattern and prevent them from being a mere jumble of empirical instructions

A difficult decision has been whether or not to use the eponyms in which plastic surgery abounds Eponyms are an essential part of everyday surgical shorthand and they recall men who have stood as signposts along the way of an advancing specialty But often they lack precise meaning and they are liable to cause confusion, firstly because they sometimes have different meanings in different countries, secondly because they are frequently used loosely so that in some instances a name has even come to be applied to a procedure different from that

PART ONE

THE BASIC TECHNIQUES

CONTENTS

PART ONE

THE BASIC TECHNIQUES

PART TWO

THE SURGICAL APPLICATIONS

PART ONE

THE BASIC TECHNIQUES

CHAPTER ONE

Wound Care

GIVEN accurate skin approximation and freedom from infection epidermal healing occurs extremely rapidly but the healing processes which go on in the dermis are much more prolonged and as far as the ultimate appearance of the resulting scar is concerned far more important The transition from fibrin clot to the quiescent relatively avascular scar takes place relatively slowly over a period of months

Initially the scar is often red and the immediate surroundings are frequently indurated almost wooden in consistency Gradually the induration and redness diminish and disappear leaving a soft scar paler than the surrounding skin The degree of redness and induration is extremely variable as is the time taken for the reaction to subside 3 months to almost a year are the extremes The appearance of a scar can be expected to improve up to a year and at least the greater part of the reaction should be allowed to subside before secondary revision is considered

This gradually diminishing induration constitutes normal progress to quiescence Such a sequence is by no means invariable and instead the fibrous tissue of the dermis may become grossly hypertrophic giving rise clinically to a raised red *hypertrophic* scar or when the reaction is more florid to a *keloid* scar but these conditions are sufficiently important to merit separate consideration

During the healing phase the tensile strength of the wound gradually increases The sutures take what little strain there is until they are removed and if a scar is going to stretch thereafter it does so gradually over the next few weeks Support of the wound for as long as is feasible appears to have little effect Naturally a scar is most likely to stretch badly when skin has been lost and there is obvious wound tension but often stretching occurs when there is no apparent tension other than that deriving from the normal elasticity of the skin

Nevertheless in many parts of the body the direction of the scar appears to influence the amount of stretching which takes place and the directions which result in minimal stretching can be systematised into **lines of election for scars.** Langer's lines, which map the direction of fibrous tissue bundles in the dermis, have been described as indicating such lines of election, but

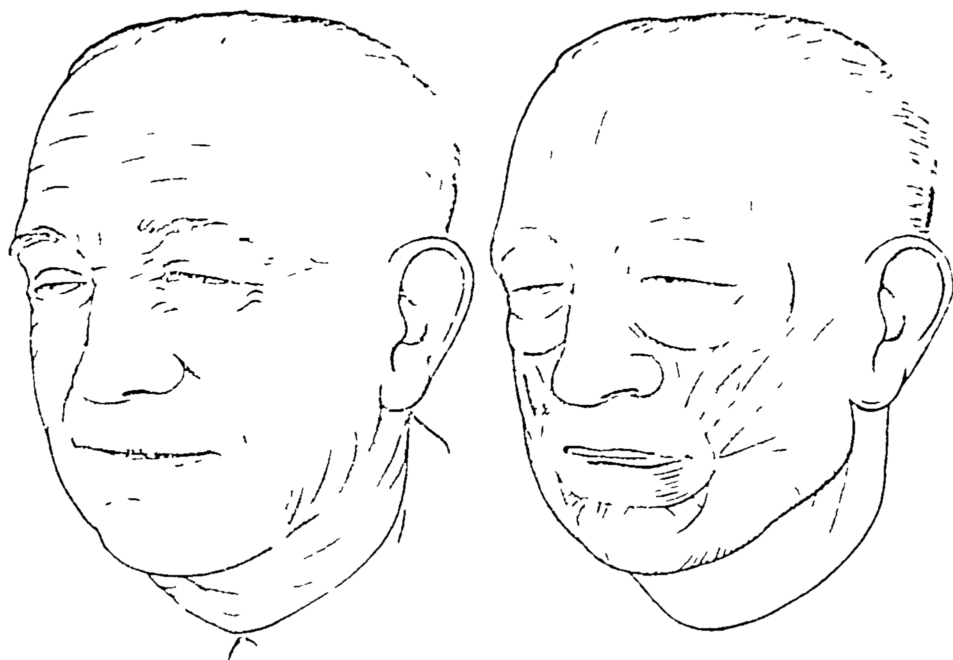


FIG 1, 1

The lines of election for scars in the face and neck shown by the pattern of wrinkling and their relation to the direction of the underlying muscles

critical examination of the diagrams of Langer's lines shows that more often than not they bear no relation to the actual line of election and it would appear that any coincidence of the two sets of lines is entirely fortuitous Unfortunately most surgeons use the term Langer's line when in actual fact they mean the line of election and the term as a result dies extremely hard

In the face and neck the lines of election are at right angles to the direction of the resultant pull of the muscles of facial expression and with the loss of elasticity that goes with ageing they become set into a pattern of wrinkles (Fig 1, 1) In the vicinity of the flexures the lines of election are parallel to the skin creases which are clearly present in the region of the flexure

In the skin surfaces between the flexures the evidence for a

specific line of election is less clear-cut and in any case the placing of an incision there is determined more often by considerations other than the eventual cosmetic result of the scar

In general then a scar should be placed in a line of election where at all possible

At the outset it must be said that there is great and uncontrollable individual variation in healing characteristics and this sets a limit to what can be achieved by pure surgical technique It is impossible to get a perfect scar always but to produce the best result in a given set of circumstances a meticulous technique is essential and it must be emphasised that failure in a single aspect is enough to give a poor result however careful all others may be

The factors concerned in wound care are

1 Placing the Scar
2 Preparing the Wound
3 Stitchcraft
4 Post operative Care

PLACING THE SCAR

When the onus of placing the scar lies with the surgeon the principles to be followed in selecting site and direction are

Use of natural lines

The scar should be placed in the line of a wrinkle or at least parallel to it (Fig 1, 1) so that in course of time it will settle in to look like another wrinkle Failing this the line of election for the particular area should be chosen

Where there is a natural junction to distract the eye from a scar this may be used In approaching the parotid for example the best scar line results from an incision along the junction of ear and masseteric region

Placing the scar where it will not be seen

The obvious examples are inside the hair line or in the eyebrow and these are the only sites where an incision which is not perpendicular to the skin surface is permissible Instead the incision should be made parallel to the hair follicles to avoid the hairless scar which sectioning hair follicles would cause The eyebrow incision is especially useful in approaching a dermoid cyst of the lateral canthal region and the invisible scar more than compensates for the added technical difficulty of such an indirect approach

Use of the Z-plasty

The use of the Z-plasty in correcting contractures is discussed in Chapter Two It has however a very definite place as an adjunct to other methods designed to minimise scars The Z-plasty is not recommended for use in the primary treatment of wounds resulting from trauma unless the wound approximates in character to a surgical incision and the circumstances are otherwise ideal It

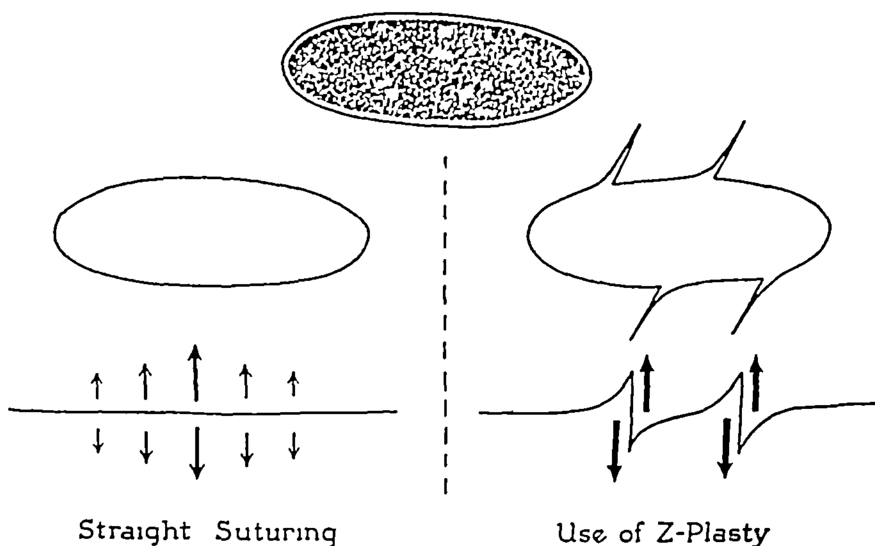


FIG 1, 2

The tension directly across a wound converted by Z-plasties into a shearing strain taken by the transverse limb of each Z

should rather be reserved for use in any subsequent revision of the scar The Z-plasty is carried out by transposing the flaps resulting from two side cuts made at 60° angles on each side of the line of excision (Fig 1, 9) and it has the following attributes and uses

Redistribution of tension Frequently following an operative procedure a wound has to be sutured under some tension and it is in such circumstances that severe stretching of the resulting scar is prone to occur Various procedures have been described as helping to avoid such an occurrence and of these the Z-plasty is probably the most valuable where it can be used (Fig 1, 2) Its effect is to break up a long scar with tension directly across the wound into multiple short scars in which tension has been redistributed in such a fashion that the greater part is taken as a shearing strain by each transverse limb of the Z-plasties It

would appear that shearing strains cause much less stretching of the scar than does straight tension

Equalisation of wound length It happens not infrequently that the two sides of a wound to be sutured are unequal in length as in excision of a comma shaped scar While the taking of unequal bites of either side can partially equate the lengths there is a definite limit to this The Z-plasty can then be used to reduce the discrepancy in length (Fig 1, 3)







Fig 1 3

Equalising the lengths of the two sides of a wound previously unequal by the use of Z-plasties

Breaking the scar line In most situations a scar tends to be noticeable if it is long and straight However narrow it may be the eye takes it for the scar that it is With Z-plasty insets on the other hand the appearance (Fig 1, 4) is of short scars interspersed with unobtrusive cross limbs giving at best a series of unconnected short scars with virtually invisible cross-limbs or at worst a zig zag scar which in practice is far less conspicuous than the original straight scar

This breaking of the line is a most important factor in scar camouflage and the more accurately the cross-limb is placed in a good line of election or actual wrinkle the less conspicuous will it be and the better the end result Where a scar crosses the nasolabial fold the cross-limb of the Z should always lie in the line of the fold likewise Z-plasties to fit the forehead wrinkles are often worth while to break a vertical forehead scar (Fig 4, 30)

When it is in a line of election and particularly in a wrinkle a long straight scar as in thyroidectomy may of course be entirely acceptable but in the face where the problem has its real relevance there must be few long straight scars which fail to cross a line of election at some point and which would not be improved by incorporating a Z-plasty

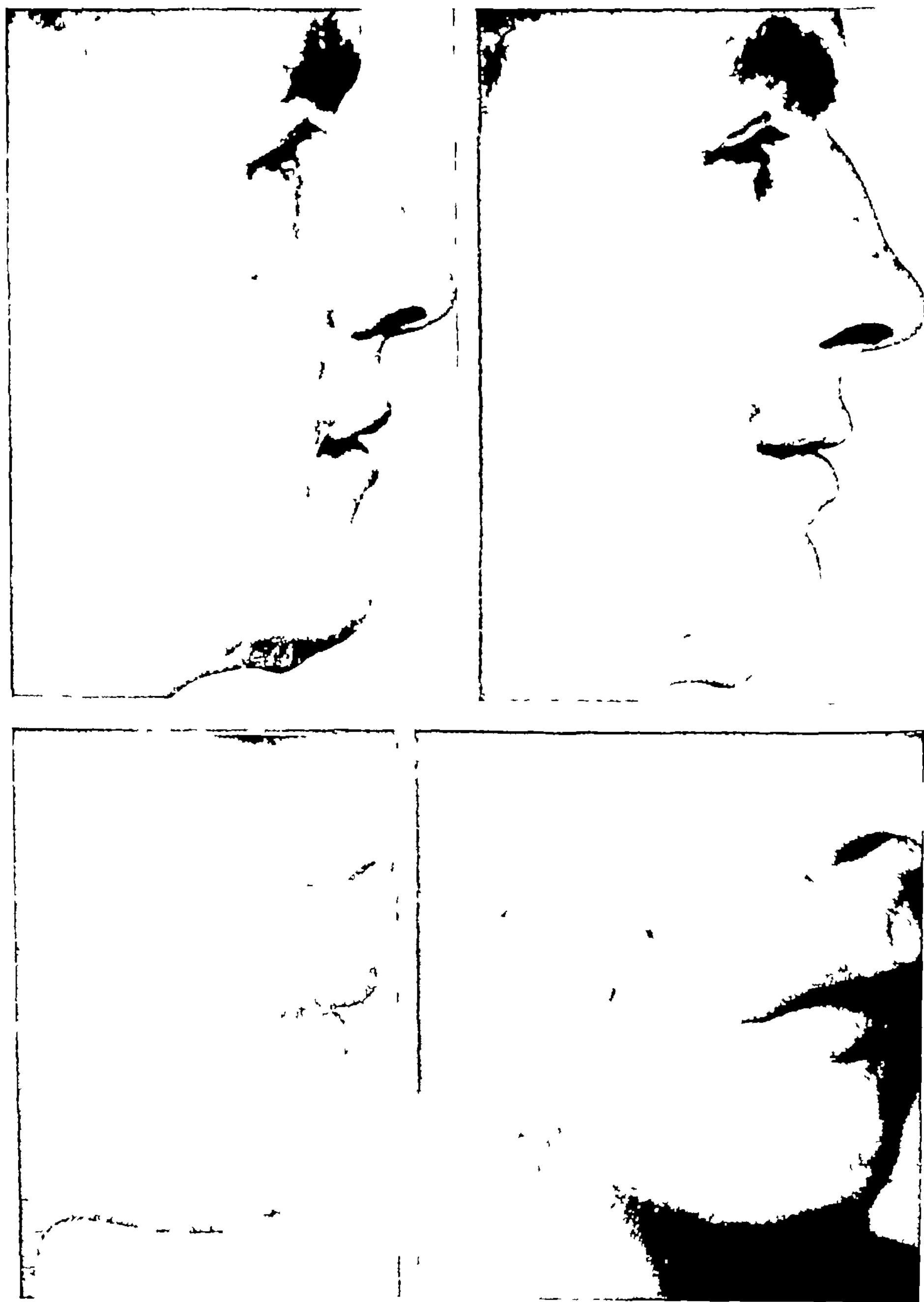


FIG. 1, 4

Breaking the line of long straight scars by incorporating Z-plasties

Crossing a hollow Where an incision crosses a hollow as in the submandibular region straight suturing invariably produces a ridged or bridle scar bridging the hollow and the only way to



FIG 1 5

The use of Z-plasties in revising a bridle scar crossing a concavity

induce such a scar to sit into the concavity is to place a Z (Fig 1, 5) at the deepest part of the hollow (see also Fig 5, 15)

The curving scar This may present a difficult problem and is seen in its worst form when a trapdoor of skin has been lifted



FIG 1 6

The recurrence of trap-door scarring following simple excision and suture

and merely resutured in place Contraction of the resulting scar causes elevation of the tissue within its concavity Seen later it may be assumed not unreasonably to be the result of bad suturing but excision of the scar trimming of the flap quite flat

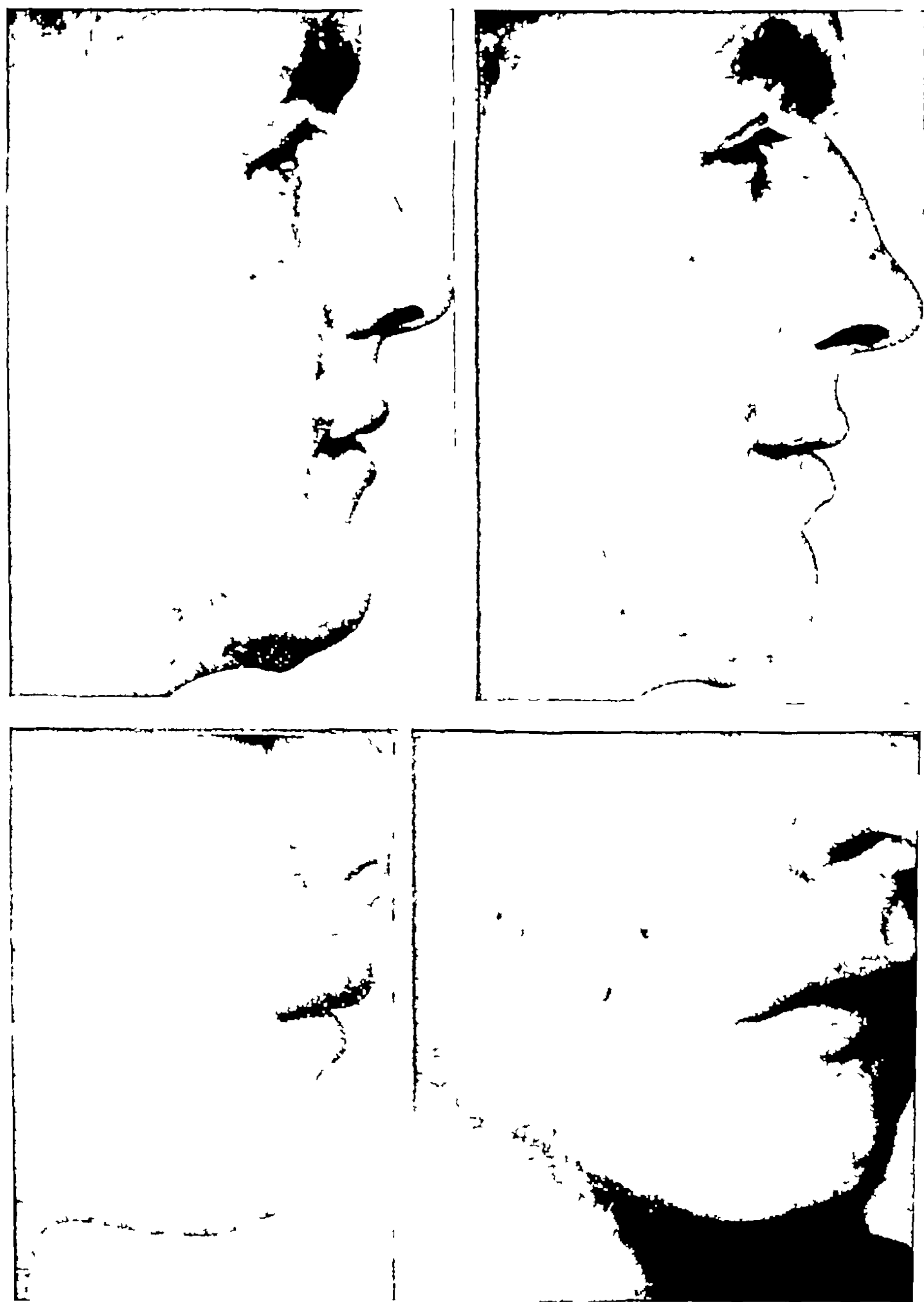


FIG 1, 4

Breaking the line of long straight scars by incorporating Z-plasties

and resuture with the greatest of care only results in recurrence of the original state of affairs within a matter of weeks (Fig 1, 6) The solution of the problem lies in the judicious use of the Z-plasty to break the curve of the scar (Fig 1, 7)

Where there is a tendency to overriding of the tissues of one side of a scar it can usually be corrected by incorporating a Z-plasty when the scar is being excised (Fig 1, 8)

Siting the Z-plasty To place a Z-plasty in the best line requires sound judgment and depends to some extent on the purpose which it is to serve In general the resulting transverse limb across the line of the scar should lie in a line of election or in the line of a wrinkle where one exists When the purpose is to sit a scar into a hollow the transverse limb should be placed to lie at the deepest part of the hollow

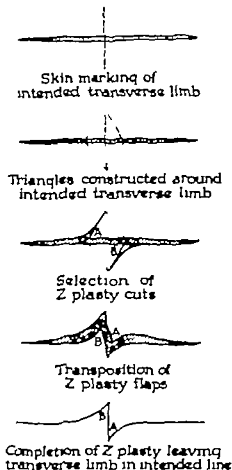


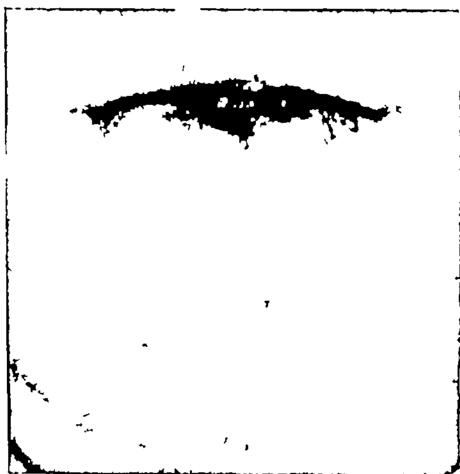
Fig 1 9

The method of siting a Z-plasty

Having decided the best line for the Z the problem of placing the appropriate incisions still remains

If mistakes are to be avoided the planning of such a Z-plasty must be regarded as a formal procedure (Fig 1, 9) to be marked out on the skin before any incision is made When the best transverse line has been selected it should be marked on the skin with Bonney s Blue (Pig Tinctorium B P C) If in planning the actual Z-plasty incisions each is made to end on this line transposition of the flaps will automatically leave the transverse limb lying along the line as planned.

With the desired transverse line marked on the skin an



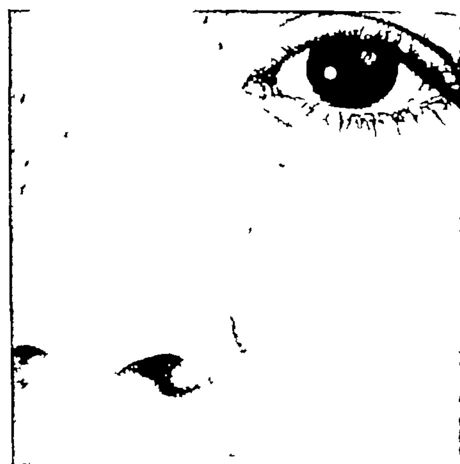
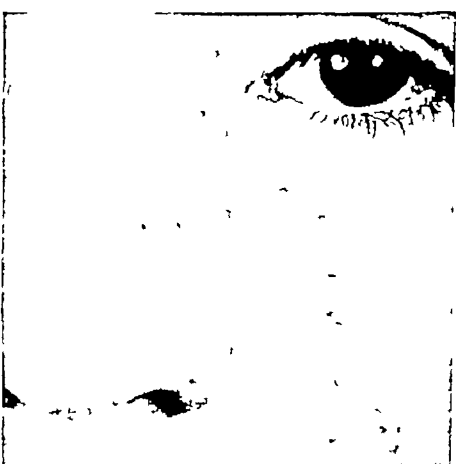



FIG 1, 7

Correction of trap-door scarring following excision and incorporation of Z-plasties

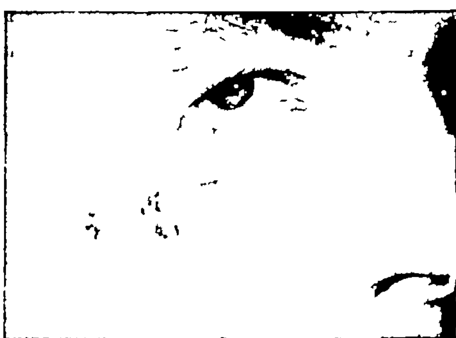



FIG 1, 8

The incorporation of Z-plasties during revision of the scar at the margin of a flap, coupled with thinning of the flap, has the effect of giving a smooth junction between the flap and its surroundings

the cosmetic result is of paramount importance the problem of excisional policy is more difficult than elsewhere and there are two approaches to the problem

If damage is minimal the wound may be excised so converting it to an atraumatic type in an attempt to get a final result primarily



FIG 1 10

The conservative treatment of severe soft tissue injuries of face involving eyelids nose and mouth where there is no skin loss showing the results of accurate tissue replacement with careful matching

This approach is satisfactory only under optimal conditions However it the result is not acceptable the situation can always be retrieved by secondary scar excision provided too much skin has not been excised in the first instance

In more extensive wounds (Fig 1, 10) the approach is more conservative Only dirt and obviously non viable tissues are removed In these circumstances one accepts the need

equilateral triangle should be drawn on each side of the scar into which the Z-plasty is being placed so that an apex of each triangle is on the transverse line already marked Of the two possible pairs of Z-plasty flaps outlined in this way the appropriate one can be chosen in the knowledge that as each incision ends on the transverse skin marking transposition of the flaps will place the transverse scar along the line intended

This method works particularly well when the wound is perpendicular, or nearly so, to the line of election or wrinkle for then the points are practically directly opposite and the triangles are easy to construct As the wound direction becomes closer to the line of election it becomes increasingly difficult and eventually impossible to get the transverse limb to lie in the line of election and a compromise must be reached which makes it as near to the line as possible

It takes courage for the inexperienced surgeon to wilfully increase the length of a wound already present by incorporating one or more Z-plasties but it is a technique with which anyone dealing with facial surgery should be familiar One seldom has cause to regret a Z-plasty but rather failure to use one

PREPARATION OF THE WOUND

When a wound is already present as a result for example of trauma it is still important to consider how and to what extent it transgresses the principles of placing a scar which have been formulated and whether it can be modified better to fit those principles When as often happens it proves impossible or undesirable to make it conform as a primary manoeuvre because of potential infection, poor blood supply of wound margins, skin damage, etc , the aim then is to prepare it for the time when, at a later date, it *can* be modified to conform

Wounds can be regarded as *traumatised* when the wound edges have been appreciably damaged or *non-traumatised* when the wound edges contain minimal damaged tissue as in surgically created wounds

It is the presence or absence of damaged tissue which determines whether or not a wound should be excised Under all circumstances it is axiomatic that all dirt and other foreign material must be removed, by excision if necessary In the face where

granulation for the resulting scar however ugly can always be excised whereas the presence of suture marks makes excision infinitely more difficult

3 Failure to suture the various wound edges in the precise position relative to one another which they occupied before



FIG 1 11

Examples of tattooed scarring resulting from failure to remove ingrained dirt and grit from the wound at the time of the injury At this late stage such tattooing is virtually impossible to eradicate completely

the injury (Fig 1, 13) The resulting irregularities are especially obvious when the lip margin, eyelid eyebrow or nostril are the structures which have been imperfectly matched

It is often important to know when a piece of traumatised tissue can safely be conserved or whether it must be excised and in deciding this the important factor is vascularity Blanching on pressure and the presence of dermal bleeding are both evidence of an active circulation In doubtful cases the anatomy of the region together with the size and content of the pedicle help in making a decision (Fig 1, 14) In the face and scalp where the problem

further surgery in the knowledge that a good scar cannot be expected from the healing of such a wound This policy permits the salvage of tissue which might otherwise be excised, tissue which may be valuable later

A conservative policy is obligatory in the care of severe facial soft tissue trauma where it is seldom possible to achieve final reconstruction at the primary operation and where the over-riding object must be to replace structures in their normal position and suture them there The secret in suturing an irregular wound is first to look for landmarks on either side to match With two points which definitely fit sutured together fresh parts of the jig-saw fall into place until enough key points have been matched to allow the intervening sutures to be placed readily Time spent fitting a jig-saw of tissue accurately at the time of original suture is never wasted, since such a chance comes only once and if it is missed the results can be disastrous Although it may be quite obvious that Z-plasties will be required later, these should seldom be used at the primary operation

An added difficulty arises when there has been actual loss of tissue and the principle which then governs practice is to replace surviving tissues in their correct anatomical position so that the defect can be properly displayed and assessed in terms of tissues lost

While the experienced plastic surgeon may legitimately carry out a primary definitive repair in such circumstances the less experienced surgeon should be more modest and if the defect cannot be closed by direct suture he should apply a split-skin graft in most instances A full-thickness defect opening into the mouth which cannot be closed without undue distortion calls for suture of skin to mucosa

These temporary measures have at least the merit of allowing rapid healing with minimal scarring and leave conditions suitable for a definitive repair subsequently

The common errors in treating wounds at this stage are

1 Failure to remove *all* dirt from the wound leaving an area of tattooed scarring (Fig 1, 11) which is usually difficult and often impossible to eradicate later

2 The production of a scar with gross suture marks (Fig 1, 12) Such a wound would often do better to heal by

arises most acutely the vascular abundance is on the side of survival and flaps should not lightly be excised Indeed in the scalp a flap with any attachment at all should be conserved



FIG I 14

Example of survival and non-survival of traumatic flaps in the face treated conservatively

A, and B Flaps before suture showing extent of injury
C Survival and non-survival of flaps
D Late result prior to reconstruction of ala of nose

In preparing a wound for suture the wound edge should be vertical if the best scar result is to be achieved and as a corollary of this surgical incisions must also be made vertical Accurate suturing is also very much easier when the faces of tissue brought

B



FIG 1, 12

Cross-hatched suture marks caused by coarse sutures left in for too long Such scarring is difficult or impossible to remove completely

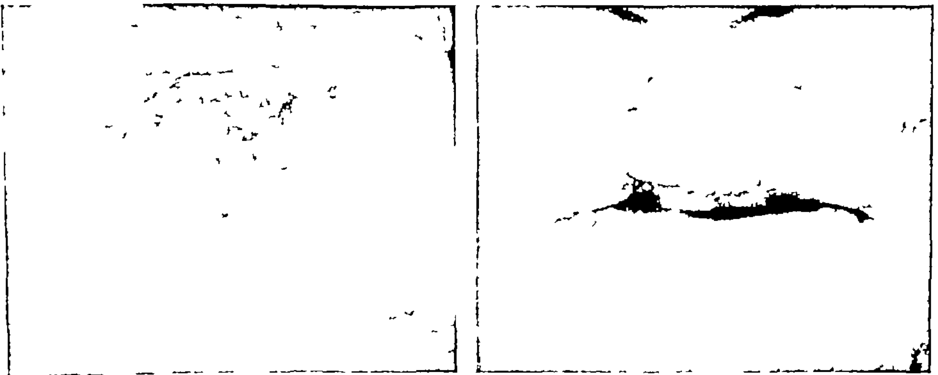
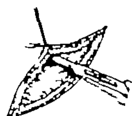
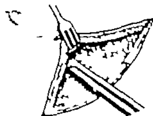


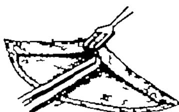
FIG 1, 13

Examples of irregularities of eyelid and mouth resulting from failure to suture matching points together accurately

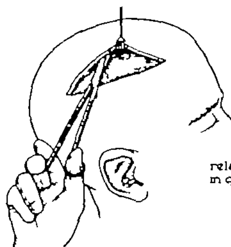


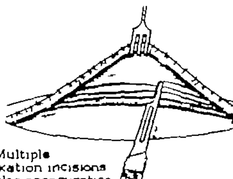












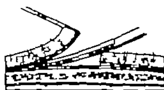


FIG 1 15

The methods and levels of undermining in the face limbs and trunk and scalp

together are of the same thickness If the wound is being sutured without tension all that may be required to prepare the skin edges is to undercut each edge for $\frac{1}{8}$–$\frac{1}{4}$ inch to allow slight wound eversion

When there *is* tension steps can be taken in preparing the wound to eliminate it or at least prevent its worst consequences by

Undercutting (Fig 1, 15) This allows a degree of advancement of the skin In undercutting, level is important and depends on the vascularity of the flaps and on the depth of important nerves On the face, and it is the area where the problem most often arises, the appropriate level is just deep to the dermis, for any undercutting must be superficial to the level of the branches of the facial nerve The blood supply is excellent in the head and neck and necrosis is unlikely to follow undercutting at even such a superficial level In the scalp the plane between galea aponeurotica and pericranium is used and multiple relaxation incisions in the deep surface of the galea aponeurotica give a little added advancement Elsewhere it is wiser if undercutting has to be more than minimal to use the plane of cleavage between superficial and deep fascia

Z-plasty The use of the Z-plasty in this situation has already been discussed and when the method is employed it is naturally used in conjunction with undercutting

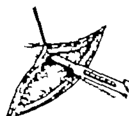
If it is clear that even with maximal undercutting closure will not be achieved the usual procedure especially in the case of a traumatic wound is to use a free skin graft On occasion a more complicated flap procedure may be feasible but as a general rule it is not a good method for emergency use The free skin graft is safer and simpler

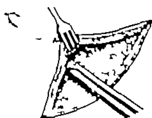
STITCHCRAFT

When the surgeon is aiming to make his scar as inconspicuous as possible the actual suturing of the wound becomes an extremely precise procedure and good results cannot be expected unless the suture materials, the needles and the instruments are suitable

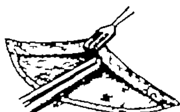
Suture Materials

There is considerable variation in the properties of the different suture materials and these properties determine which particular

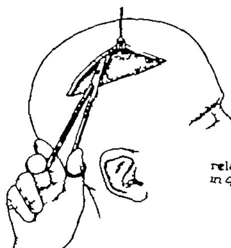












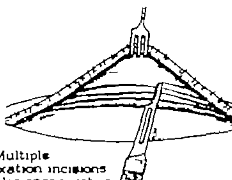




Fig 1 15

The methods and levels of undermining in the face limbs and trunk and scalp

material is the appropriate one in a given situation The commonly used threads are

Braided silk. This material is easy and pleasant to work with, yet the surface is sufficiently rough for knots to hold reasonably well especially with an initial double turn It is normally supplied waterproofed and this is said to reduce reaction around the suture holes

One of its defects is a relatively low tensile strength and if much tension is needed, as for tie-over sutures, it is apt to break in the sizes used, namely 3–0 and 5–0 When the best cosmetic result is essential the finer thread is used but with even minimal tension such a thread breaks readily and 3–0 may be required The finest thread which can be used will give the best cosmetic result

Linen Its relatively rough surface makes the handling qualities of linen less satisfactory than silk Some samples also tend to be slightly irregular in diameter though this has been much less common recently Its tensile strength is much greater than silk of comparable diameter and the rough surface makes its knot-holding properties much better than those of silk Its size is approximately 3–0 and it can be used instead of 3–0 silk if preferred For tie-overs its knotting properties and strength make it preferable

Stainless steel wire. Stainless steel wire 34 and 36 S W G is very useful on occasion quite apart from its use in tendon suturing It is inert in the body and has a very high tensile strength but until the technique has been acquired it is awkward to use for kinking occurs readily and creates a weak point in the wire Though it can replace any type of skin suture material it is much less satisfactory than silk or linen for ordinary interrupted sutures Its main usefulness is as a tension suture or as a continuous intradermal or "over and over" suture Used as a continuous "over and over" suture its rigidity prevents it from "bunching" the skin as silk and linen tend to do It is also useful when sutures must be left in for longer than usual for its inertness reduces reactions around the sutures to a minimum

Cat-gut To help relieve tension cat-gut has been recommended as a buried suture Its use is discussed on page 28

Silk worm gut and nylon. Used for interrupted sutures silk worm gut is unsatisfactory as it lacks the desirable quality of pliability Its smooth surface on the other hand makes it easy to remove when it is used as a continuous intradermal suture Monofilament nylon is pliable and inert but its knotting properties are so poor that it is rarely used for interrupted skin sutures It is useful as a continuous intradermal suture

Needles

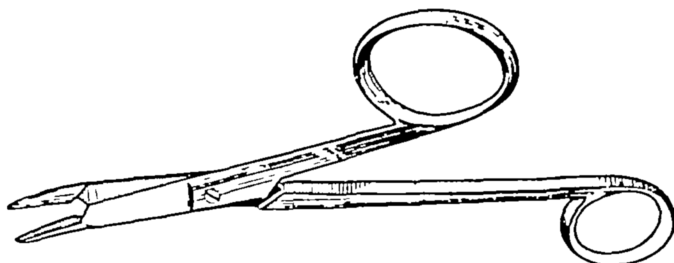
Although in theory an atraumatic suture should do less damage to the skin during its insertion the large number of sutures needed would make the cost prohibitive and it is extremely unlikely that their use would make a significant difference in practice Other deficiencies of technique are usually present to explain failure to get the best result Nos 3 and 5 eye curved cutting needles are most generally useful for fine suturing and require minimal effort in use If greater strength is required a thicker needle is naturally used

Instruments (Fig 1, 16)

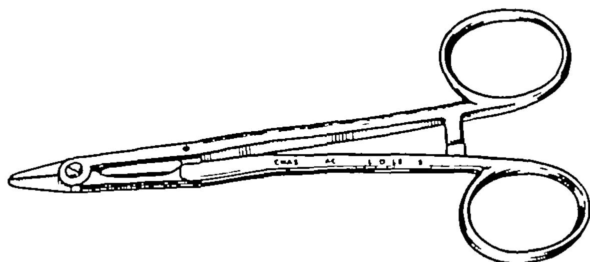
The instruments concerned are **needle-holders, dissecting forceps skin hooks** and **scissors**

It is preferable to use the instrumental method of suture tying (Fig 1, 17) for the small needles and fine suture materials make tying by hand clumsy and difficult With instrumental tying tension can be regulated and knot placement carried out with much greater finesse exactitude and expedition after only a little practice The needle holders normally used in general surgery are quite useless Large cumbersome and ill designed for the necessarily fine work of careful skin suturing the locking mechanism in particular makes them impossible to use for knot tying The Gillies or Kilner needle holders are essential and though it takes a little time to acquire facility particularly with the Gillies holder it is a most rewarding facility to have

The more a wound edge is traumatised the less good will be the cosmetic result and so the implements for holding wound margins steady for suturing must be as atraumatic as possible The skin hook is the least traumatic instrument though its method of use described below is a difficult one to use with elegance and speed Because of this dissecting forceps are more routinely used



Gillies Combined Scissors and Needle Holder



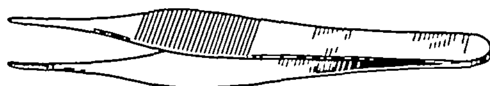
Kilner's Needle Holder



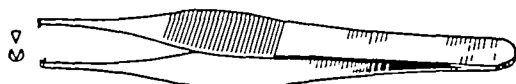
McIndoes Dissecting Forceps *(non-toothed)*



Gillies' Dissecting Forceps *(toothed)*



Adson's Dissecting Forceps *(non-toothed)*



Adson's Dissecting Forceps *(toothed)*



Gillies' Skin Hook

Fig. 1, 16

The instruments used in skin suturing

individual preference will decide the choice of the toothed or non toothed varieties but both should be used with due regard to the trauma they are causing The McIndoe and Gillies dissecting

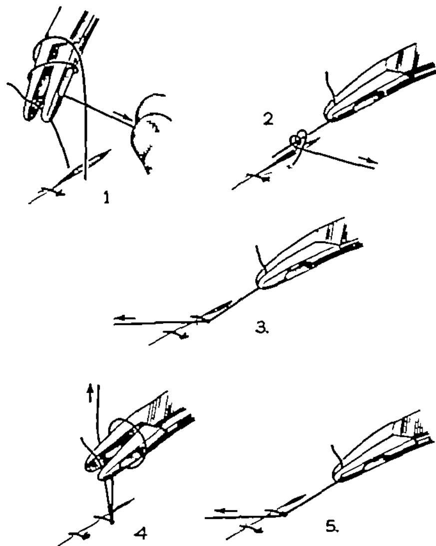


FIG I 17

Instrumental tying of a suture

forceps are of a suitable size for routine suturing but for really fine work Adson forceps are much superior

Two types of scissors are usually employed straight sharp-pointed for cutting wound margins and suture removal curved blunt pointed for undercutting wound edges Both should be sharp so that the tissues are cut cleanly and not crushed

Technique of Wound Suture

The aim is to produce a wound atraumatically but absolutely accurately co-apted and technique of handling and suturing is merely a means to this end First-time accurate placing of the suture is a habit to acquire, the second attempt is all too often worse than the first and only results in a moth-eaten wound edge and poor scar The needle is curved and so moves most readily in a circle The wrist must therefore be brought freely into play

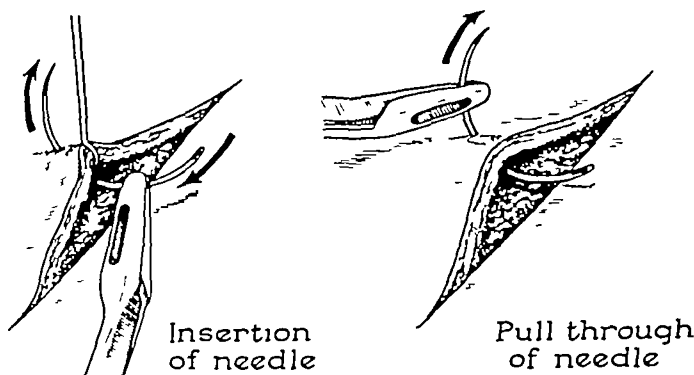


FIG 1, 18

The insertion and pull through of a needle in the line of the curve of the needle

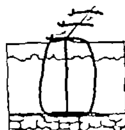
so that insertion and pull through of the needle are always in the line of its curve (Fig 1, 18)

For a definite period after a wound is sutured slight oedema of the wound tends to develop and though it can be reduced by a pressure dressing, allowance must be made for it in tying the suture If the suture is too tight it will surely cut in more rapidly and make a suture mark The correct suture tension just avoids blanching the skin held by the suture

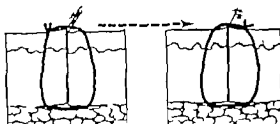
Sutures may be *interrupted* or *continuous* When the cosmetic result is all important the interrupted suture is best but the continuous is often adequate in other circumstances, e g delay of flap or pedicle

Interrupted sutures The usual suture is the **simple loop suture** (Fig 1, 19) which consists of a simple loop knotted at one or other side of the wound and it aims to bring the skin edges together absolutely accurately with no overlapping of one margin A general tendency towards slight "pouting" of the suture line

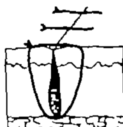
helps to ensure complete dermal apposition and makes sure that inversion of the wound edges is avoided Inverted wound edges always heal more slowly and give a poorer scar and it is to allow the desired degree of eversion that a skin edge is sometimes undermined for $\frac{1}{8}$–$\frac{1}{4}$ inch



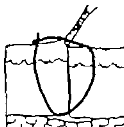
Equal bite is the coarse adjustment



Placing the knot as a fine adjustment



Insufficient deep bite producing inversion and dead space



Unequal bite producing poor apposition of the wound edges

FIG I 19

The simple loop suture

The suture should include at least the whole dermis and if the wound flap includes superficial fascia particularly outside the face this should also be taken so that the needle has an equal bite of each side The taking of an equal bite might be termed the coarse adjustment of getting the wound edges level Not infrequently however one or other edge is a shade higher than its fellow and the lower side can be raised a little by manipulating the knot in tying to that side of the wound Every suture has an optimal side for its knot and its manipulation is the fine adjustment

By making the suture take a slightly greater bite of the deeper part dermis or fat the whole face of wound margin is approximated

and the very slight eversion achieved When a curved needle is used the wound edge is held everted (Fig 1, 20) and the needle directed so that its path will make a curve in the appropriate direction when the skin is allowed to fall back into its normal

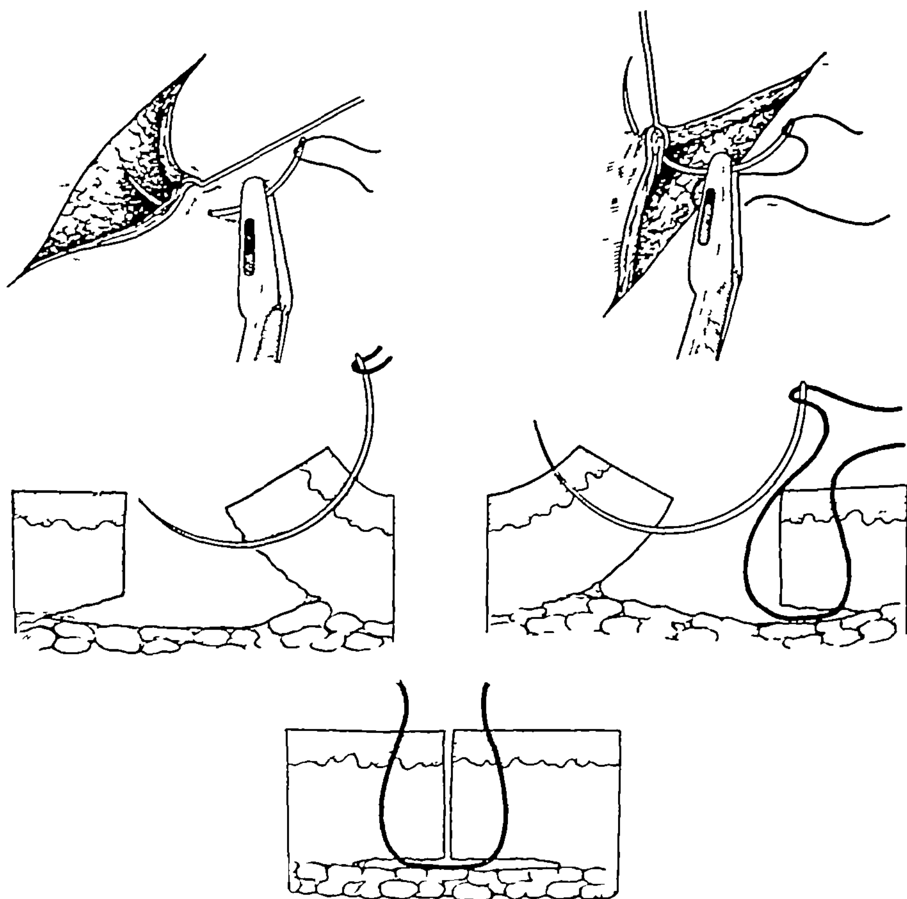
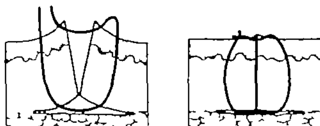


Fig 1, 20

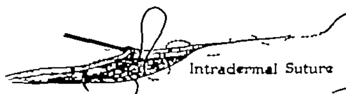
Everting the wound edge with a skin hook before inserting the needle and the path of the curved needle in the skin

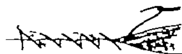
position This eversion is carried out with the least trauma when a skin hook is used It is technically much easier as a rule to suture from the more mobile side of the wound to the more fixed side

Where the skin is thin and poorly supported or mobile on its deep surface, e g around the eyelids, it is particularly difficult to avoid inversion and the best solution is often to use the **vertical mattress suture** (Fig 1, 21) This suture has no greater tendency









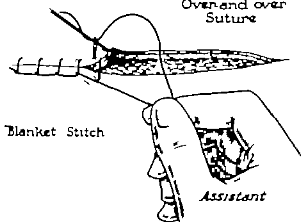


Fig 1 21

Commonly used types of skin suture

and the very slight eversion achieved When a curved needle is used the wound edge is held everted (Fig 1, 20) and the needle directed so that its path will make a curve in the appropriate direction when the skin is allowed to fall back into its normal

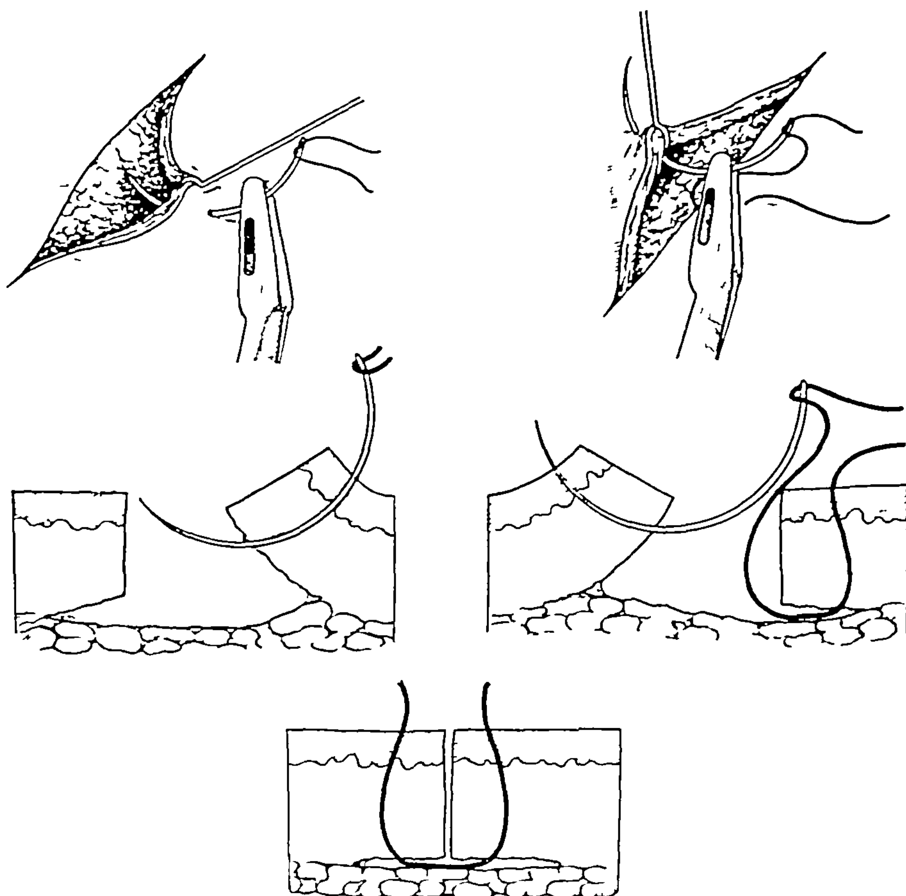


FIG 1, 20

Everting the wound edge with a skin hook before inserting the needle and the path of the curved needle in the skin

position This eversion is carried out with the least trauma when a skin hook is used It is technically much easier as a rule to suture from the more mobile side of the wound to the more fixed side

Where the skin is thin and poorly supported or mobile on its deep surface, e g around the eyelids, it is particularly difficult to avoid inversion and the best solution is often to use the **vertical mattress suture** (Fig 1, 21) This suture has no greater tendency

Distribution of Wound Tension

When a wound is tending to distort and it is difficult to distribute the tension evenly on both sides for suturing it often helps to make the wound taut with a skin hook in each end so that a few key sutures can be placed accurately before inserting the intervening sutures When distortion is to be expected and especially in a

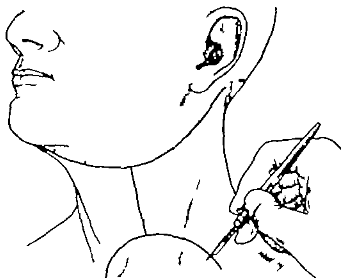


FIG I 22

Tattooing matching points with Bonney's Blue before skin incision to facilitate subsequent suturing

curved incision trouble will be saved by tattooing matching points with Bonney's Blue (Fig I, 22) on either side of the projected incision before any cut is made

The Three-point Suture (Fig I 23)

Where a triangular flap has to be inset it is often difficult to get the tip of the flap to lie in position yet multiple sutures placed through the full thickness of the dermis are apt to strangulate the tissue at the tip and produce necrosis The three point suture in such a situation helps to avoid necrosis while holding the tip in place As frequently described the suture tends to bunch the tip of the flap and a minor variation is recommended which is theoretically sound and effective in practice in holding the tip without

to leave stitch marks than any other if the sutures are not tied too tightly and are removed early, and if the superficial bite is minimal the tendency to invert is corrected

When there is no tension of the wound the interrupted suture alone is adequate When there is tension two possible additional measures are described which are said to allow early removal of skin sutures without wound disruption or stretching

Buried cat-gut sutures (Fig 1, 21) Interrupted buried cat-gut sutures with the knot placed deeply are used with the idea of taking strain after early removal of skin sutures Their ability to prevent wound stretching is rather doubtful, the result is usually as good or bad as might have been expected had they not been used Their main value is probably to eliminate dead space and prevent haematoma

Continuous intra-dermal suture (Fig 1, 21) This suture has the merit that it can be left in for 10–12 days without leaving suture marks Though it may be used by itself it will be found that really accurate skin edge apposition is only possible if additional interrupted skin sutures are used Its role then is to take any tension from the interrupted sutures and silk-worm gut, nylon or stainless steel wire can all be used

While these methods are used and recommended in text-books their value is very limited and the Z-plasty used in conjunction with extensive undercutting is more effective If these are not practicable or cannot be employed to the full some degree of stretching is probably inevitable

Continuous sutures. The most useful continuous sutures are the "**blanket stitch**" and the **continuous "over and over"** (Fig 1, 21) With silk or linen the "blanket stitch" has the advantage of not "bunching up" the wound and can also be locked with a knot at any point The "over and over" suture does tend to bunch the wound unless stainless steel wire is used, its rigidity being sufficient to prevent this occurring Naturally such sutures cannot be placed quite as accurately as the interrupted suture but where an impeccable scar is not essential they certainly save time It is sometimes stated that the continuous suture tends to strangulate the wound edge but this is due to unduly tight insertion rather than any inherent defect of the method

Length of Scar and the "Dog-ear"

When an oval or circular lesion is excised and the defect closed by direct suture the resulting scar is always considerably longer than the original lesion, a fact which it is always wise to explain to the patient. This is so for two reasons:

1. When the curved lines (ellipse up to circle) resulting from

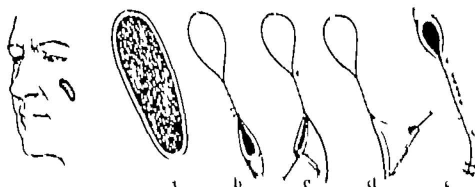


Fig. 24.

Removal of a "dog-ear". Following excision of the lesion (a), the skin defect is sutured (b) until the "dog-ear" becomes apparent. The "dog-ear" is defined with a skin hook and the skin is incised (c) round the base. Excess skin is defined and removed (d) and the skin is sutured (e).

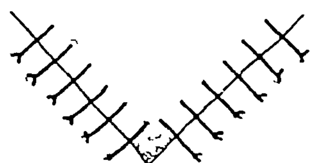
the excision are brought together in a straight line the result naturally is lengthening of the scar.

2. When the ellipse following excision is sutured there is almost invariably at each end of the suture line a "dog-ear" and the correction of this lengthens the scar still further.

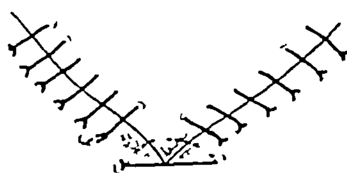
To remove a "dog-ear" (Fig. 24) the wound should be sutured until the elevation becomes pronounced. A hook placed in the end of the wound and raised then defines the extent of the "dog-ear". The elevation is then excised by incision around the base on one or other side ending up in the line of the wound. The resulting flap is brought across the wound so that the excess skin can be defined and removed. The resulting line has a slight curve and its direction, which depends on the side of the dog-ear cut initially, can be chosen to fit the best line cosmetically. Failure to remove the dog-ear leaves a rather unsightly swelling (Fig. 25) and though it flattens somewhat with the passage of time it does tend to remain prominent enough to mar an otherwise satisfactory result.

bunching The points to be noted in inserting the suture are

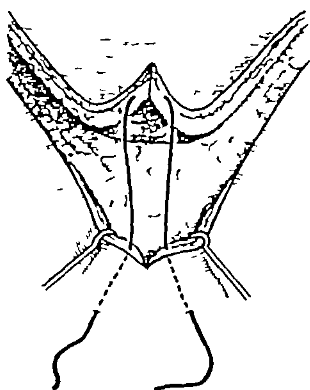
1 To make sure that the suture leaves and enters the reception side of the wound at the same level as its placement in the V flap

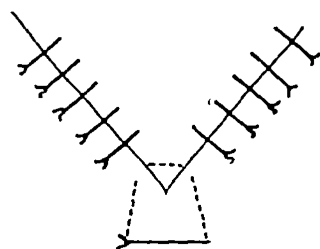


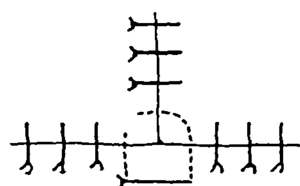
Suture strangulation causing flap tip necrosis

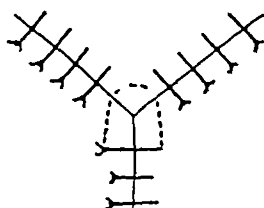


Incorrect placing of suture causing "bunching" of flap tip









Method of insertion and applications of the three point suture

FIG 1, 23

The three-point suture

2 To make the suture emerge well back on the reception side of the wound

The principle of the 3-point suture can be extended for use where two flaps are being approximated to the third side of a wound

replace the crepe bandage in suitable circumstances and the adhesive properties of the elastoplast can be greatly enhanced by preliminary painting of the skin with Mastisol

Suture removal It is usual to lay down set days for the removal of sutures in various sites and under varying circumstances but

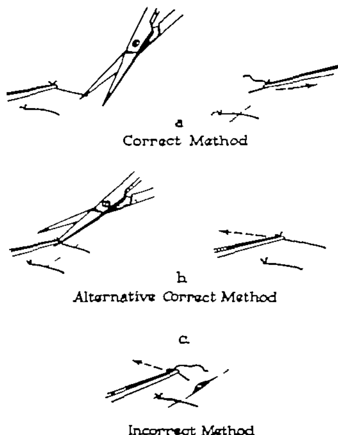


Fig 1 26

Suture removal In (a) and (b) strain on the wound is avoided by pulling the cut suture *towards* the line of the wound while in (c) the suture pulled *away* from the wound increases the tension and liability to wound dehiscence

this is quite a wrong approach Clinical experience soon tells the surgeon when a suture may safely be removed Naturally the principle is to remove at the earliest time judged safe and this depends on so many factors degree of tension site line of wound etc that it is quite impossible to lay down rules In actually removing the suture (Fig 1, 26) one must remember that the

POST-OPERATIVE CARE

The aim of good post-operative treatment is to **prevent haematoma, provide rest for healing** and **prevent suture marks** In practice this is achieved by the dressing, care in suture removal and later support of the wound

The pressure dressing. With extensive undercutting it is difficult despite meticulous haemostasis to prevent a haematoma



Fig 1, 25

The result of failure to excise a "dog-ear"

unless a pressure dressing is used The pressure dressing also provides the immobility and splinting which create the best conditions for rapid, uneventful healing and controls the oedema which begins the cutting-in process of a suture Unless there is a good reason it should be left intact until the time comes for suture removal In the face where there has been minimal undermining, particularly around the mouth, the advantages of a pressure dressing may be more than outweighed by the almost inevitable contamination with food and saliva and it is often found that exposure of the wound gives a better result It is then essential to keep the suture line dry and free of blood clot until the fibrin clot covering the line of the wound is firm and dry

The wide mesh of a *single layer* of tulle gras allows the passage of any discharge and this combined with the vaseline base make it a particularly good dressing next the wound as it permits the dressing to be removed with the minimum of trauma from sticking Over the tulle gras, gauze and wool followed by a crepe bandage will give adequate, cushioned pressure and immobility Elastoplast may

replace the crepe bandage in suitable circumstances and the adhesive properties of the elastoplast can be greatly enhanced by preliminary painting of the skin with Mastisol

Suture removal. It is usual to lay down set days for the removal of sutures in various sites and under varying circumstances but

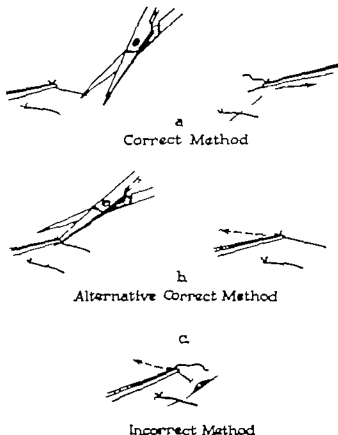


Fig 1 26

Suture removal In (a) and (b) strain on the wound is avoided by pulling the cut suture *towards* the line of the wound while in (c) the suture pulled *away* from the wound increases the tension and liability to wound dehiscence

this is quite a wrong approach Clinical experience soon tells the surgeon when a suture may safely be removed Naturally the principle is to remove at the earliest time judged safe and this depends on so many factors degree of tension site line of wound etc that it is quite impossible to lay down rules In actually removing the suture (Fig 1, 26) one must remember that the

c

tensile strength of the wound is minimal and dehiscence is liable to occur on the slightest provocation Where most care is needed the sutures are usually smallest and therefore before beginning there must be a *good light*, fine, sharp scissors *which cut to the point* and fine dissecting forceps *which grip properly* With these prerequisites the actual technique of removal is not radically different from ordinary suture removal except that absolute gentleness is necessary and the cut suture being pulled out must always be pulled out *towards* the wound

Subsequent support of the wound As already stated, early suture removal leaves a wound devoid of strength so that a sudden ill-judged tension strain may cause it to open For this reason the wound is best supported or at least protected up to a week after stitch removal It is seldom practicable to support the wound much beyond this and indeed attempts to prevent later stretching of the wound by prolonged support are of little avail

KELOIDS AND HYPERTROPHIC SCARS

When a scar, instead of becoming soft and pale in the usual manner, becomes red and thickened it is described as being either a *hypertrophic scar* or a *keloid*

These terms tend to be used rather indiscriminately, probably because it is difficult to define each with certainty The typical hypertrophic scar is raised, rather red initially, but does not encroach on the surrounding normal skin, does not give rise to symptoms, and shows an eventual tendency to regress The keloid tends to be a much more florid lesion, it is grossly elevated, tends to spread and involve the surrounding normal skin, and gives rise to symptoms of itching, a feeling of hotness, and tenderness to touch

These are the extremes and as such easily recognised but in reality there is an infinite gradation from the completely quiescent scar through the very midly hypertrophic scar to the most severe of keloids and the point at which a hypertrophic scar becomes a keloid is a matter of opinion The name is fortunately of subsidiary importance for the treatment of both conditions is similar Indeed the gradation rather suggests that the arbitrary division into keloid and hypertrophic scar is artificial and that the

conditions are really a single entity of varying severity Virtually nothing is known of the cause

The clinical picture. A precise picture is difficult to draw for clinical generalisations do not necessarily apply to the individual



Fig 1 27

Change from keloid to hypertrophic scarring over a period of 2 years The keloid scarring (A) arose as a complication of an extensive degloving injury of leg The worst area of keloid was excised and replaced with a split-skin graft but in the areas left untouched (B) the lessening of activity is obvious

case and the condition itself is extremely variable and unpredictable In the description which follows the term keloid will be used to cover both conditions

The tendency to develop keloids diminishes greatly with age but it is not possible in practice to forecast whether any particular patient will develop a keloid Nevertheless any incision in a

tensile strength of the wound is minimal and dehiscence is liable to occur on the slightest provocation Where most care is needed the sutures are usually smallest and therefore before beginning there must be a *good light*, fine, sharp scissors *which cut to the point* and fine dissecting forceps *which grip properly* With these prerequisites the actual technique of removal is not radically different from ordinary suture removal except that absolute gentleness is necessary and the cut suture being pulled out must always be pulled out *towards* the wound

Subsequent support of the wound As already stated, early suture removal leaves a wound devoid of strength so that a sudden ill-judged tension strain may cause it to open For this reason the wound is best supported or at least protected up to a week after stitch removal It is seldom practicable to support the wound much beyond this and indeed attempts to prevent later stretching of the wound by prolonged support are of little avail

KELOIDS AND HYPERTROPHIC SCARS

When a scar, instead of becoming soft and pale in the usual manner, becomes red and thickened it is described as being either a *hypertrophic scar* or a *keloid*

These terms tend to be used rather indiscriminately, probably because it is difficult to define each with certainty The typical hypertrophic scar is raised, rather red initially, but does not encroach on the surrounding normal skin, does not give rise to symptoms, and shows an eventual tendency to regress The keloid tends to be a much more florid lesion, it is grossly elevated, tends to spread and involve the surrounding normal skin, and gives rise to symptoms of itching, a feeling of hotness, and tenderness to touch

These are the extremes and as such easily recognised but in reality there is an infinite gradation from the completely quiescent scar through the very midly hypertrophic scar to the most severe of keloids and the point at which a hypertrophic scar becomes a keloid is a matter of opinion The name is fortunately of subsidiary importance for the treatment of both conditions is similar Indeed the gradation rather suggests that the arbitrary division into keloid and hypertrophic scar is artificial and that the



Fig 1 28

Examples of keloids and hypertrophic scars

A Mildly hypertrophic scar of deltoid region
B Severe post burn hypertrophic scarring of neck and chin
C Hypertrophic scarring following the ill judged use of a vertical incision to excise a thyroglossal fistula
D Pre-sternal keloid in the male
E Pre-sternal keloid in the female showing butterfly outline
F Severe keloid of scapular region

known "keloid former" is more likely to develop into a keloid than a similar incision in a random patient and recurrence following simple excision of a keloid is highly probable Keloids are undoubtedly much more common in the negro than in the white patient The negro also exhibits the condition in its most active form and the "tumours" can on occasion reach quite grotesque proportions In the white on the other hand even the frank keloid does eventually become less active and takes on the characters and activity rather of a hypertrophic scar (Fig 1, 27)

Certain areas of the body have a particular tendency to produce keloids (Fig 1, 28), the pre-sternal area is probably the most prone of all and here oddly enough the shape of the keloid often shows a sex difference—in the male it is triangular, in the female the pull of the breasts gives it a butterfly outline The deltoid area is another notorious site It is significant that a scar may become keloid in only part of its length and this shows particularly in the neck where the vertical scar is very subject to keloid change while the horizontal scar is seldom affected This indeed is one of the facts which the various theories of causation fail to explain for if a scar of neck is excised incorporating Z-plasties it is not uncommon for the horizontal scars to be completely flat and soft while the vertical limbs of the Zs show keloid or at very least hypertrophic change In general, scars in lines of election show less tendency to keloid than those which cross them

Treatment ACTH and cortisone have been used but with disappointing results The only treatment of real value is X-ray therapy either alone or in conjunction with surgery Extreme care in dosage, shielding, etc , are necessary and there should be close co-operation between surgeon and radiotherapist It is usually found that a keloid is most sensitive to X-rays when it is red, vascular, and generally in an active state The whiter, older scar responds poorly

The problem in practice

The problem presents in one of three ways

The scar in a " neutral " area in the patient without a keloid history. This is the position of most patients and as a rule it is enough to watch carefully such scars post-operatively and warn the patient to look out for thickening of the scar so that treatment may be started at the first sign

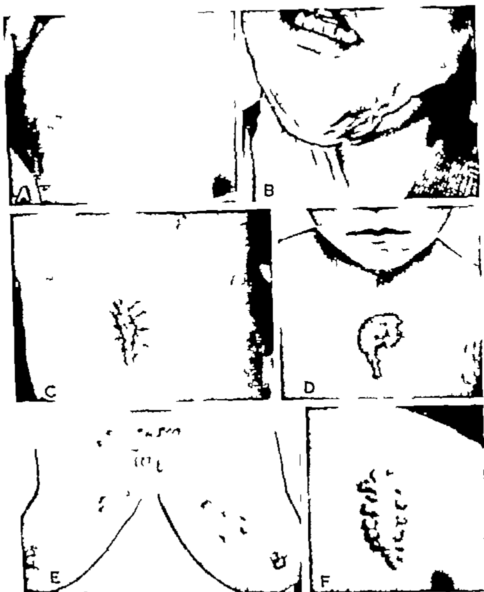


FIG. 1, 28

Examples of keloids and hypertrophic scars

A Mildly hypertrophic scar of deltoid region
B Severe post burn hypertrophic scarring of neck and chin
C Hypertrophic scarring following the ill judged use of a vertical incision to excise a thyroglossal fistula
D Pre-sternal keloid in the male
E Pre-sternal keloid in the female showing butterfly outline
F Severe keloid of scapular region

known "keloid former" is more likely to develop into a keloid than a similar incision in a random patient and recurrence following simple excision of a keloid is highly probable Keloids are undoubtedly much more common in the negro than in the white patient The negro also exhibits the condition in its most active form and the "tumours" can on occasion reach quite grotesque proportions In the white on the other hand even the frank keloid does eventually become less active and takes on the characters and activity rather of a hypertrophic scar (Fig 1, 27)

Certain areas of the body have a particular tendency to produce keloids (Fig 1, 28), the pre-sternal area is probably the most prone of all and here oddly enough the shape of the keloid often shows a sex difference—in the male it is triangular, in the female the pull of the breasts gives it a butterfly outline The deltoid area is another notorious site It is significant that a scar may become keloid in only part of its length and this shows particularly in the neck where the vertical scar is very subject to keloid change while the horizontal scar is seldom affected This indeed is one of the facts which the various theories of causation fail to explain for if a scar of neck is excised incorporating Z-plasties it is not uncommon for the horizontal scars to be completely flat and soft while the vertical limbs of the Zs show keloid or at very least hypertrophic change In general, scars in lines of election show less tendency to keloid than those which cross them

Treatment. ACTH and cortisone have been used but with disappointing results The only treatment of real value is X-ray therapy either alone or in conjunction with surgery Extreme care in dosage, shielding, etc , are necessary and there should be close co-operation between surgeon and radiotherapist It is usually found that a keloid is most sensitive to X-rays when it is red, vascular, and generally in an active state The whiter, older scar responds poorly

The problem in practice

The problem presents in one of three ways

The scar in a "neutral" area in the patient without a keloid history. This is the position of most patients and as a rule it is enough to watch carefully such scars post-operatively and warn the patient to look out for thickening of the scar so that treatment may be started at the first sign

Surgery in a known danger area or in a known keloid former There are three possible approaches to this situation—to watch the scar with extreme care and treat at the first sign, to give prophylactic treatment immediately healing is complete, or to treat the operative site before operation and afterwards the scar as soon as it has healed. The selection of the appropriate method in a particular patient will depend on an assessment of the probable likelihood of keloid developing.

The developed keloid In the worst sites, particularly the pre-sternal and deltoid areas, recurrence after excision even preceded and followed by a full course of X-ray therapy is so probable (Fig. 1, 29) that surgery should be contemplated with extreme reluctance. A bigger keloid is the most likely result. An alternative approach which has given encouraging results is to excise the keloid within its boundaries. This is at least not followed by extension of the keloid.

With the greatest care and the best treatment the results still leave a good deal to be desired. The process can be damped down rather than stopped completely and the extent to which it can be reduced depends on its inherent activity. At one end of the scale mildly hypertrophic change can be stopped completely while at the other the florid keloid in a bad site seems often to be barely influenced. Fortunately mildly hypertrophic change in scars is the most common form of the condition for it is in it that prophylaxis is most effective.

BIBLIOGRAPHY

Lines of election for scars

KRAISSL, C. J. (1951). Selection of appropriate lines for elective surgical incisions. *Plast. reconstr. Surg.* 8, 1.

Keloids and hypertrophic scars

LEVITT, W. M. (1951). Radiotherapy in the prevention and treatment of hypertrophic scars. *Brit. J. plast. Surg.* 4, 104.

MOWLEM, R. (1951). Hypertrophic scars. *Brit. J. plast. Surg.* 4, 113.

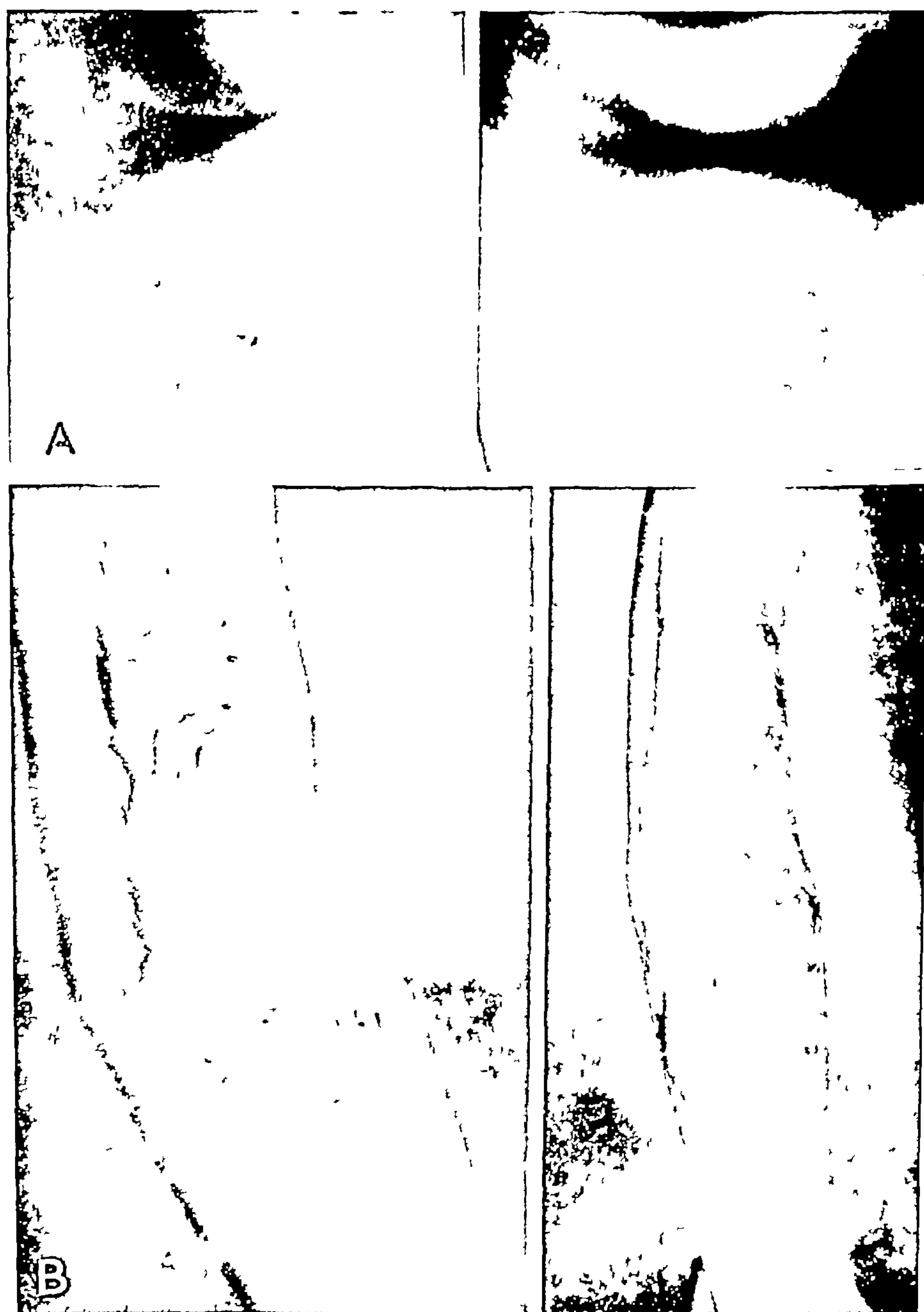


FIG. 1, 29

Marginal recurrence of keloid after excision and grafting

A Pre-sternal keloid showing recurrence both marginally and in the suture marks

B Keloid of elbow showing recurrence both marginally and centrally where small areas of graft had failed to take

Fig 2 1

The Z-plasty

Fig 2, 2

A schematic formalised representation of the several stages of the Z-plasty

CHAPTER TWO

The Z-plasty

ALTHOUGH the place of the Z-plasty in the treatment of wounds and scars has been described in Chapter One its fundamental use is in the release of contractures Used for this purpose it is a device in which, by transposing suitably constructed flaps, skin is brought from adjacent areas where there is a relative abundance, to release the contracture The theoretical basis of the method in its simplest form will be discussed before considering its applications and possible modifications in practice

THEORETICAL BASIS OF THE Z-PLASTY

The basic manoeuvre

The flaps are constructed in the form of two interdigitated triangles with a common limb giving the overall shape of a Z The common limb of the triangles, i e the central limb of the Z, lies along the line of the contracture to be released While the angles of the Z may vary within certain limits to be defined later the common angle in practice is 60° and this will be used in the present description With such a construction the triangles together give the shape of a parallelogram, the shorter diagonal in the line of the contracture, the longer diagonal perpendicular to it The two diagonals can conveniently be referred to as the **contractural diagonal** and the **transverse diagonal** (Fig 2, 1)

To carry out the manoeuvre the triangular flaps are elevated and the line of fibrous tissue causing the contracture divided With the springing apart of the divided contracture the parallelogram changes shape causing the triangular flaps to become transposed, the contractural diagonal to lengthen, and the transverse diagonal to shorten correspondingly (Fig 2, 2)

As can be seen, the length of the contractural diagonal *after* completion of the transposition equals that of the transverse diagonal *before* the transposition The lengthening of

the surrounding tissues is so great that the flaps cannot readily be brought into their transposed position

2 Even if tissue was available at either side to allow an angle larger than 60 without tension the amount of tissue turning required to transpose the flaps when the angle reaches 80–90 would tend to produce unsightly dog ears

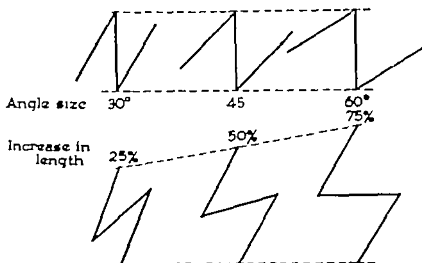


FIG 2, 3

The percentage increase of length which results from the use of different angle sizes

Limb length Just as angle size controls percentage increase of length so limb length controls the *actual* increase in length since the increase is a proportion of the original length A longer initial limb results in a greater increase of length for a particular size of angle Such an increase in the amount of lengthening naturally increases the tissue brought in from the sides

The factors which limit maximum and minimum angle size have resulted in the compromise use of 60 as the routine Z-plasty angle It is length of limb which provides the major variable in practice and regardless of length of contracture the amount of tissue available on either side determines the practicable limb length—a large amount will permit a large Z a small amount will correspondingly limit the size of the Z

In considering the availability of tissue on either side it must be stressed that the transverse shortening and the tension which it creates are concentrated along the line of the transverse diagonal

the contractural diagonal is achieved at the expense of the transverse diagonal which has become shortened to equal the original length of the contractural diagonal Translated into practical terms this means in effect that skin has been brought in from the sides, as shown by the shortening of the transverse diagonal, to achieve the lengthening of the contractural diagonal The difference in length of the two diagonals is a measure of the actual lengthening achieved

Construction of the Z

Since the skin flaps must fit together in their transposed position the limbs of the Z must of necessity be equal in length The angles of the Z are also usually made equal in size The factors in construction which do vary are **angle size** and **limb length** and the ways in which these variable factors affect the result provides an explanation of why a specific construction is used in a particular set of circumstances

Angle size In any Z-plasty once the length of the limbs of the Z has been decided the lengthening to be expected depends entirely on the size of the angle and as the angle increases so too does the amount of lengthening With an angle of 30° there is a 25 per cent increase in length, with 45° a 50 per cent increase, while with an angle of 60° the increase rises to 75 per cent (Fig 2, 3) It must be stressed that at all times it is *percentage* increase of length which is controlled by size of angle

In theory angles of up to and beyond 90° could be used with steady increase in the amount of lengthening but in practice limiting factors emerge which determine the optimal angle

An angle of much less than 60° would defeat the very object of the Z-plasty since the smaller angle would produce less gain in length, this quite apart from the precarious blood supply to the tip of a narrow flap

The factors which prevent the use of angles much larger than 60° are

1 Increase in length is achieved at the expense of the tissue on either side and as the angle increases the amount of tissue brought in from the sides is correspondingly increased As a rule the amount of tissue available is far from unlimited and as the angle increases beyond 60° the tension produced in

A good measure of the planning and execution of a Z-plasty is the behaviour of the flaps when the contracture is released If the manoeuvre is indicated and well planned the flaps should literally fall into their new transposed position indeed it should be difficult to get them back into their old relationship

It is when the contracture is of the grossly bow string type that the Z-plasty is most effective With the contracture more diffuse in breadth and length it is less satisfactory and a stage is reached where it must be decided whether a Z-plasty is an adequate procedure or whether fresh skin must be imported from elsewhere as a free skin graft The answer is usually to be found in the surrounding skin skin must come from somewhere if the contracture is to be released and if it is not obviously available at the sides (Fig 2, 5) the Z-plasty will fail and a free skin graft is the true answer to the problem

Planning the Z-plasty (Figs 2, 6 and 2, 8)

It may be difficult in planning the procedure to decide where the flaps should be A good method is to draw an equilateral triangle on each side of the contracture (see Fig 1 9) and from the resulting parallelogram to select the more suitable of the two sets of limbs One set may have no particular advantage in which case either may be used Factors which might favour one set rather than the other are

1 The flap with the better blood supply is preferable in particular one with scarring across the base should be avoided

2 One or other flap may give a scar which will fall into a better line cosmetically The factors which would influence the choice in such circumstances have already been discussed in Chapter One

3 The lie of the flaps and the surrounding skin may permit one set of flaps to rotate more readily into their transposed position

Skin which is scarred has lost much of its normal elasticity and this may affect slightly the planning of the flaps A flap of scarred skin should be made a little longer initially than its fellow of normal skin otherwise the scarred flap will be found to be too short when it is sutured to the unscarred flap

It is usual though not absolutely essential to have the two angles of equal size On occasion a line of scarring will limit the angle

of the Z (Fig 2, 4) This becomes important when methods of diffusing tension by constructing multiple small Z-plasties instead of a single large Z are considered

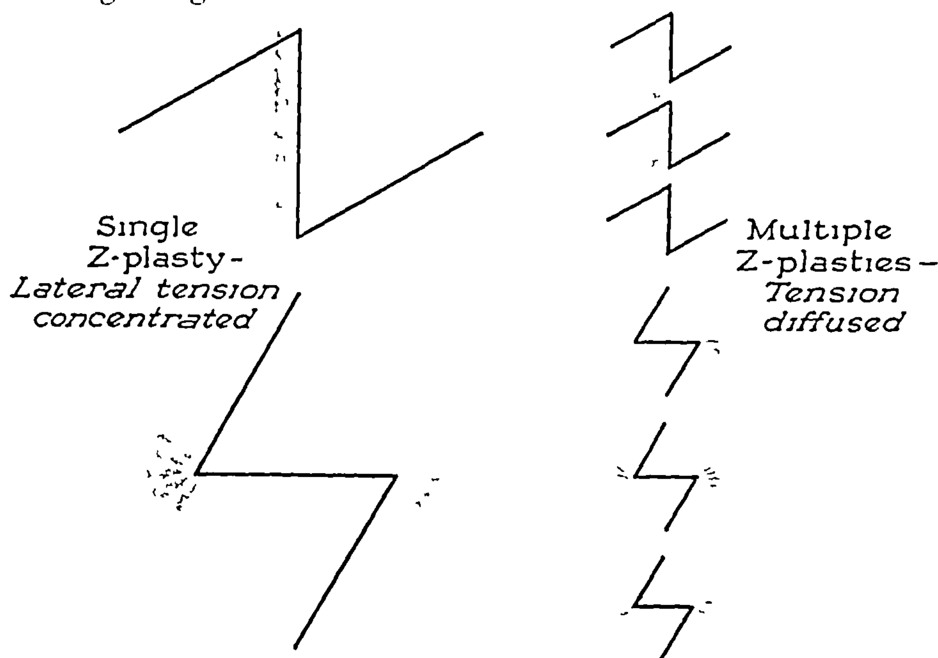


FIG 2, 4

The concentration of lateral tension by the single Z-plasty in contradistinction to the multiple Z-plasty which spreads the lateral tension over the several transverse diagonals

PRACTICE OF THE Z-PLASTY

From the theoretical discussion it follows that the Z-plasty is most effective where the contracture is narrow and the surrounding tissues are lax enough to permit a reasonably large Z to be constructed since scarred and contracted tissue on either side can yield no "slack" to allow lengthening

Ideally the central limb of the Z extends the full length of the contracture but this requires a correspondingly large quantity of tissue to be brought in from the sides, tissue which is not always available It is in the limbs particularly that this problem arises, for such tissue as is available is not concentrated at one point but is spread out along the length of the limb In such circumstances the solution may be to construct a series of short Zs instead of one large Z and so bring in from the sides small quantities of tissue all the way down the line of the contracture (Fig 2, 4)

A good measure of the planning and execution of a Z-plasty is the behaviour of the flaps when the contracture is released If the manoeuvre is indicated and well planned the flaps should literally fall into their new transposed position indeed it should be difficult to get them back into their old relationship

It is when the contracture is of the grossly bow string type that the Z-plasty is most effective With the contracture more diffuse in breadth and length it is less satisfactory and a stage is reached where it must be decided whether a Z-plasty is an adequate procedure or whether fresh skin must be imported from elsewhere as a free skin graft The answer is usually to be found in the surrounding skin skin must come from somewhere if the contracture is to be released and if it is not obviously available at the sides (Fig 2, 5) the Z-plasty will fail and a free skin graft is the true answer to the problem

Planning the Z-plasty (Figs 2, 6 and 2, 8)

It may be difficult in planning the procedure to decide where the flaps should be A good method is to draw an equilateral triangle on each side of the contracture (see Fig 1, 9) and from the resulting parallelogram to select the more suitable of the two sets of limbs One set may have no particular advantage in which case either may be used Factors which might favour one set rather than the other are

1 The flap with the better blood supply is preferable in particular one with scarring across the base should be avoided

2 One or other flap may give a scar which will fall into a better line cosmetically The factors which would influence the choice in such circumstances have already been discussed in Chapter One

3 The lie of the flaps and the surrounding skin may permit one set of flaps to rotate more readily into their transposed position

Skin which is scarred has lost much of its normal elasticity and this may affect slightly the planning of the flaps A flap of scarred skin should be made a little longer initially than its fellow of normal skin otherwise the scarred flap will be found to be too short when it is sutured to the unscarred flap

It is usual though not absolutely essential to have the two angles of equal size On occasion a line of scarring will limit the angle

Fig 2, 5

A narrow axillary contracture (A), which is suitable for correction by a Z-plasty, and a diffuse axillary contracture (B), which is unsuitable for a Z-plasty and which requires for its correction the insertion of a split-skin graft

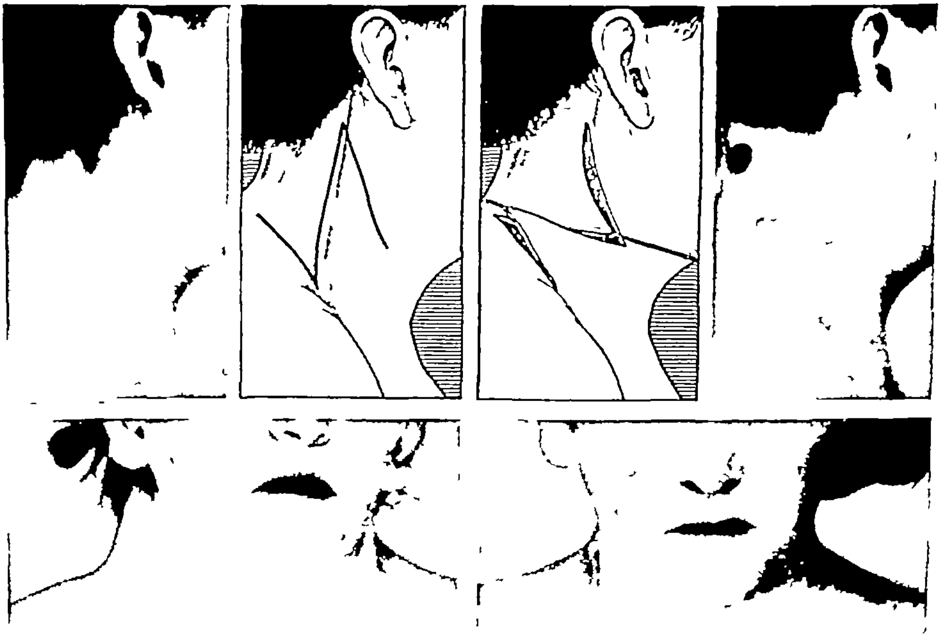


Fig 2, 6

The planning and execution of a *single* Z-plasty to correct the neck webbing component of Turner's syndrome

of one flap and dissimilar angles may then have to be used Lengthening in such a case becomes the average of the amount to be expected from each angle alone Indeed if the full quadrilateral of any Z is drawn complete with contractural and transverse diagonals the transverse diagonal will always show the actual length to be expected when the flaps are transposed

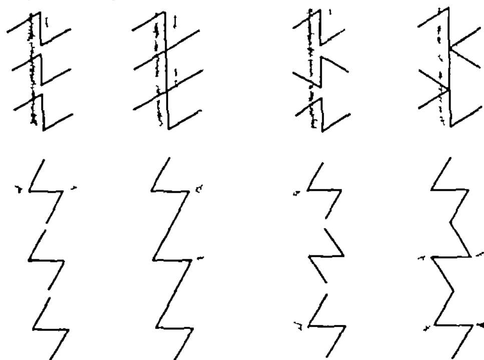


FIG 2, 7
The evolution of the parallel and skew types of the continuous multiple Z-plasty from a series of interrupted small Z-plasties

The multiple Z-plasty

When a large Z cannot be used for the reasons already discussed the alternative often lies in multiple small Zs The line of contracture can be regarded as a series of contracted segments and a small Z can be constructed for each segment Carrying such an idea to its logical conclusion (Fig 2 7) creates a **continuous Z-plasty** where the Zs instead of being individual form a continuous series giving the appearance of a long line along the contracture with multiple Z side limbs (Fig 7, 5) The Zs can be constructed with the side limbs either parallel or skew The

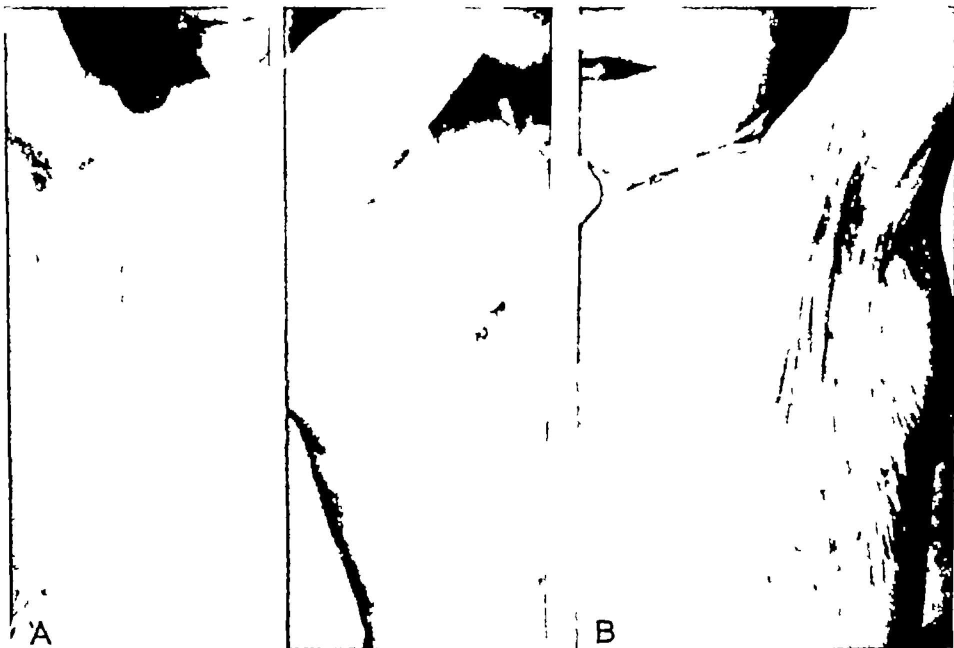


Fig 2, 5

A narrow axillary contracture (A), which is suitable for correction by a Z-plasty, and a diffuse axillary contracture (B), which is unsuitable for a Z-plasty and which requires for its correction the insertion of a split-skin graft

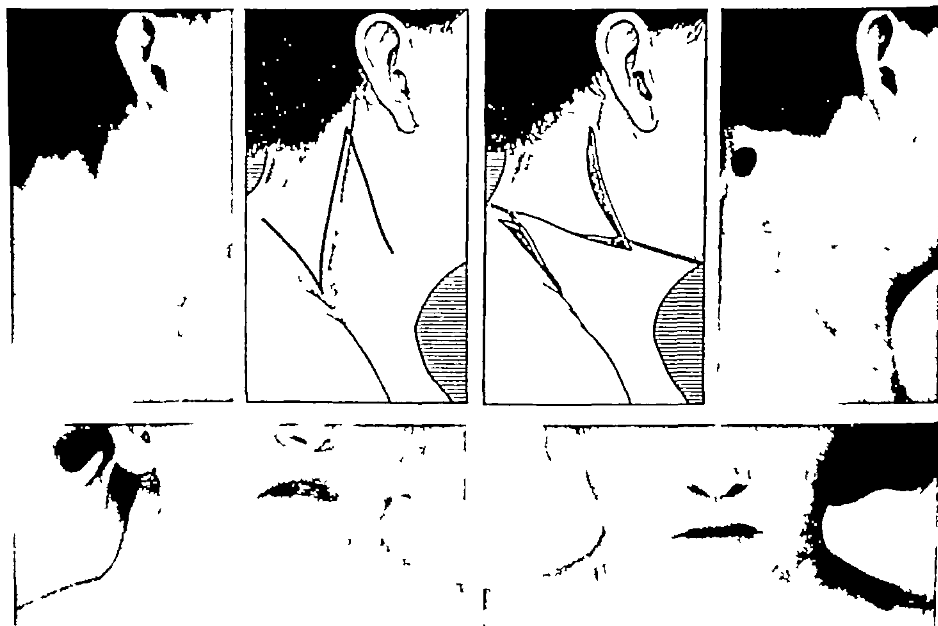


Fig 2, 6

The planning and execution of a *single* Z-plasty to correct the neck webbing component of Turner's syndrome

the base and by cutting the flaps as thick as possible The flap tip can be broadened without affecting the angle size by slightly modifying the shape of the flap (Fig 2, 9) The thickest flap practicable should always be cut using the levels of undermining suggested in Chapter One

Avoidance of undue tension This can be a very difficult problem particularly when the contracture is a doubtful candidate for

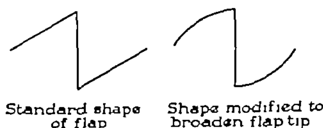


Fig 2, 9

The modified shape of Z-plasty flap to give maximum vascular capacity

Z-plasty or free skin graft The large single Z concentrates transverse tension while multiple small Zs diffuse the tension making it less at each individual Z so that embarrassment of the circulation from this cause is reduced to a minimum

While the contracture may be placed under tension during the procedure to display its line and extent the parts should be dressed and bandaged in a mid position to promote relaxation of tissues in all directions

Meticulous haemostasis Haemostasis avoids the disaster of haematoma adding to any tension and undue pressure of dressings either or both of which can cause necrosis

BIBLIOGRAPHY

DAVIS J S & KITLOWSKI E A (1939) The theory and practical use of Z-incision for relief of scar contractures *Ann Surg* 109, 1001

LIMBERG A A (1946) *Mathematical principles of local plastic procedures on the surface of the human body* Leningrad Medgis This monograph contains by far the most exhaustive and authoritative discussion of the Z-plasty both its theory and practice

MCGREGOR I A (1957) The theoretical basis of the Z-plasty *Brit J plast Surg* 9, 256

presence of scarring in a particular line may influence the construction and make skew flaps preferable but the use of parallel limbs allows uniform rotation of the flaps in transposing and prevents the occurrence of the broad tipped flap with the narrow base which is undesirable from a vascular point of view and inevitable with the skew construction

Whether a multiple Z-plasty must be used will largely depend

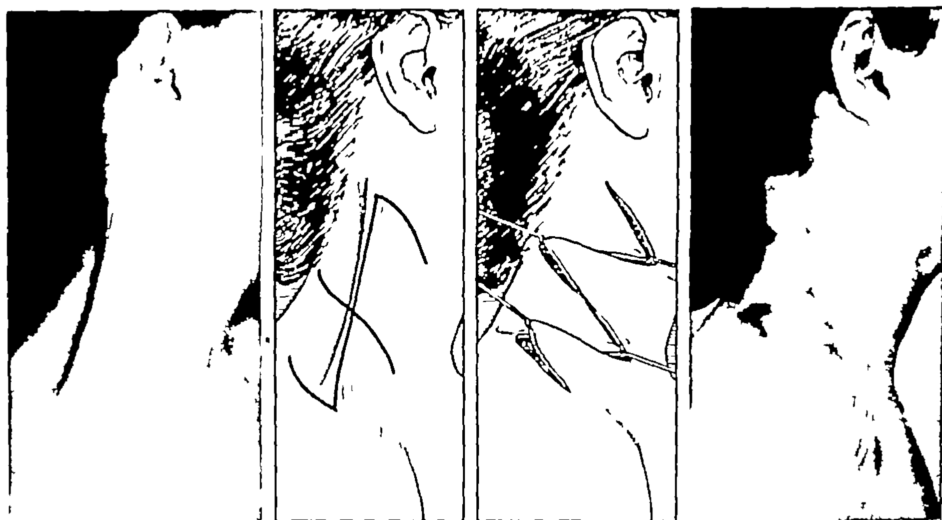


FIG 2, 8

The planning and execution of a *multiple* Z-plasty in correcting a localised post-burn contracture of neck

on the depth of the bow-string It is unwise to take the side-limbs much beyond the base of the bow-string and if the making of a large Z would encroach on the surrounding flat skin to any extent especially if it tends to be taut, then a multiple Z-plasty (Fig 2, 8) is safer and on the whole just as effective

Blood supply of the flaps

The most frequent complication of the Z-plasty is necrosis of the tip of a flap and it is particularly common if there has been much scarring of the skin Precautions to avoid necrosis can be taken at all stages of the procedure, by providing the flaps with the maximum of vascular capacity, by avoiding tension and by meticulous haemostasis

Provision of maximum vascular capacity This is achieved by designing the flaps broad at the tip, by avoiding scarring across

Free skin grafts (Fig 3, 1) are of two kinds

1 **Whole skin graft** consisting of epidermis and the full thickness of dermis

2 **Split-skin graft** consisting of epidermis and a variable quantity of dermis Split skin grafts are described as *thin intermediate* or *thick* according to the amount of dermis included

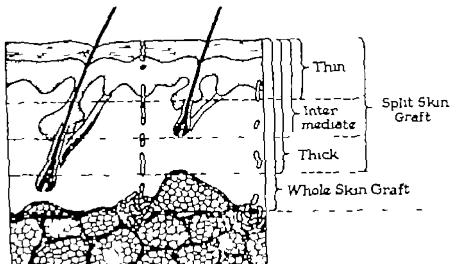


Fig 3, 1

A transverse section of skin showing the thickness and components of the various types of free skin graft

While the properties of the whole skin graft are relatively constant those of the split skin graft depend in some degree on the thickness of its dermal component the thicker split skin graft approximating to the whole skin graft in its characteristics

The whole skin graft takes less readily than the split skin graft and before it can be used successfully conditions must be optimal The thinner the split skin graft the better are its chances of taking in difficult conditions

The stability of a graft depends on dermis and so the thicker graft stands late trauma better than the thin graft

The whole skin graft remains virtually at its original size the split skin graft tends to contract if circumstances permit e.g inside the mouth or across a flexure Within broad limits the thinner a graft the more it will contract secondarily

The donor site of the split skin graft heals spontaneously

CHAPTER THREE

Free Skin Grafts

AS a result of trauma, pathological process, or surgical excision the surgeon may be faced with a defect of skin which, because of its size, cannot be closed by direct suture or which, because of its other characteristics, is unsuitable for suture He must then consider whether alternative skin cover is possible and if it *is* possible what form it should take On most occasions the skin cover of choice will be a free skin graft though circumstances do arise where a free skin graft cannot be used and a flap is needed The indications for the use of a flap will be discussed in Chapter Four, the present discussion is concerned primarily with the use and practice of free skin grafting

As its name implies a free skin graft is completely detached from the body during its transfer from donor to recipient site It is used in circumstances which vary enormously and examples of these are

1 Where there is loss of skin following trauma Grafting may be carried out *primarily*, immediately after the traumatic episode, or *secondarily*, when granulations have developed

2 Where a residual skin defect is left following excision of a simple or malignant tumour

3 Where an ulcer, e g gravitational, caused by a non-neoplastic pathological process, is present

As a general rule a free skin graft will be accepted by any site which, left ungrafted, would rapidly develop granulations Although most often used to repair a skin defect, such a graft can also cover a defect of the mucosa of the accessible mucous membrane lined cavities—mouth, eye, accessory sinuses, etc

been inadequately studied in the human but in general thick grafts are less rapidly vascularised than thin The anatomical lay-out of dermal capillaries may explain this for the density of the capillary network of the superficial dermis is much greater than that of the deeper dermis In a thin graft the greater density of cut capillary ends will greatly increase the chances of meeting of the capillaries of graft and graft bed with consequent rapid union and vascularisa tion on the basis of mere random link up for there is no evidence that chemotactic influences play any part in vascular link up

Factors Influencing Take

Take depends on rapid vascularisation and to achieve this certain requirements must be met

1 A recipient site capable of producing capillary buds
2 *Accurate approximation of graft and recipient site so that* the granulation tissue zone between the two surfaces is reduced to a minimum
3 Immobilisation during the phase of vascularisation

The recipient site Capillary outgrowth is needed both to produce granulation tissue and to vascularise a graft and so the **potential recipient area incapable of producing granulations will not take a free skin graft.** As a corollary of this the surface which granulates rapidly and well takes a graft readily one which granulates poorly takes a graft less readily

The parallel shows well when fat and deep fascia are compared for just as deep fascia granulates better and more rapidly than fat so it provides a better bed for grafting The need for capillary outgrowth from the graft bed means also that a free skin graft will not take on *tendon bared of paratenon* on *denuded cortical bone* or on *cartilage* (Fig 3, 3)

Granulations become less vascular and more fibrous as they age and the sooner they are grafted the better the chance of take Infection tends to complicate the issue in such a situation for the longer a granulating area remains ungrafted the greater are its chances of infection which will vitiate graft take

Accurate approximation. The shorter the distance to be travelled by the capillaries outgrowing from graft bed and graft dermis to join each other the more rapid and effective will be the development of a circulating system in the graft This makes it

while that of the whole skin graft has either to be closed by suture or covered with a split-skin graft This places a limit on the area of whole thickness skin which can usefully be cut

TAKE AND VASCULARISATION

By definition a free skin graft must be without blood supply until the vessels of graft and recipient area link up At normal skin temperatures a skin graft without an effective blood supply

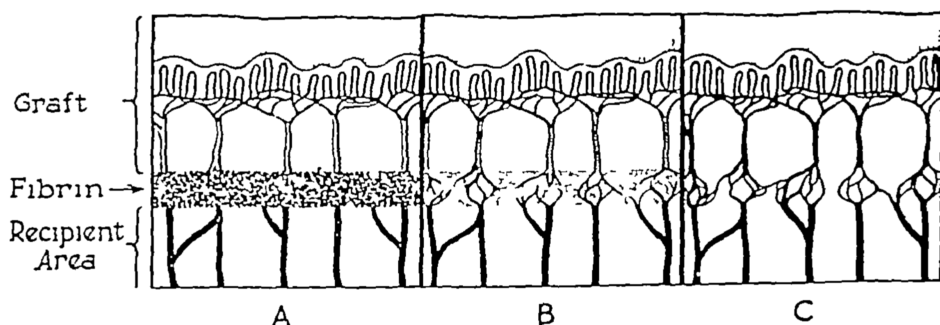


Fig 3, 2

A diagrammatic representation of graft take

A Initial anchorage by fibrin
B Commencing organisation of fibrin clot with ingrowth of capillaries from graft bed and graft
C Link-up of blood vessels of graft and graft bed, and organisation of fibrin into fibrous tissue attachment

has a limited survival time and so the rapid provision of such a supply is vital The process of attachment to the recipient area and vascularisation of the graft are referred to as "take" of the graft

Initially there is a link-up between the capillaries of graft and recipient area (Fig 3, 2) This initial linkage is said to be re-inforced by fresh ingrowing vessels from the graft bed so that the vascular pattern of the graft is re-organised but the evidence for this is not very substantial The initial link-up is usually well advanced by the third day At this time the attachment of the graft to its bed is very tenuous and remains so until the initial fibrin clot anchorage has become organised into a fibrous tissue attachment, a process which takes some time The graft must be protected during this period lest rupture of linking capillaries occur with resulting haemorrhages under the graft

The speed and actual process of vascularisation of grafts has

been inadequately studied in the human but in general thick grafts are less rapidly vascularised than thin The anatomical lay out of dermal capillaries may explain this for the density of the capillary network of the superficial dermis is much greater than that of the deeper dermis In a thin graft the greater density of cut capillary ends will greatly increase the chances of meeting of the capillaries of graft and graft bed with consequent rapid union and vascularisa tion on the basis of mere random link up for there is no evidence that chemotactic influences play any part in vascular link up

Factors Influencing Take

Take depends on rapid vascularisation and to achieve this certain requirements must be met

1 A recipient site capable of producing capillary buds
2 Accurate approximation of graft and recipient site so that the granulation tissue zone between the two surfaces is reduced to a minimum
3 Immobilisation during the phase of vascularisation

The recipient site. Capillary outgrowth is needed both to produce granulation tissue and to vascularise a graft and so the **potential recipient area incapable of producing granulations will not take a free skin graft** As a corollary of this the surface which granulates rapidly and well takes a graft readily one which granulates poorly takes a graft less readily

The parallel shows well when fat and deep fascia are compared for just as deep fascia granulates better and more rapidly than fat so it provides a better bed for grafting The need for capillary outgrowth from the graft bed means also that a free skin graft will not take on *tendon bared of paratenon* on *denuded cortical bone* or on *cartilage* (Fig 3 3)

Granulations become less vascular and more fibrous as they age and the sooner they are grafted the better the chance of take Infection tends to complicate the issue in such a situation for the longer a granulating area remains ungrafted the greater are its chances of infection which will vitiate graft take

Accurate approximation. The shorter the distance to be travelled by the capillaries outgrowing from graft bed and graft dermis to join each other the more rapid and effective will be the development of a circulating system in the graft This makes it

essential to have intimate contact of the graft and its bed, and the commonest cause of separation of the two surfaces is blood clot (Fig 3, 4) which forms a barrier through which capillaries cannot grow in time to prevent necrosis of the graft

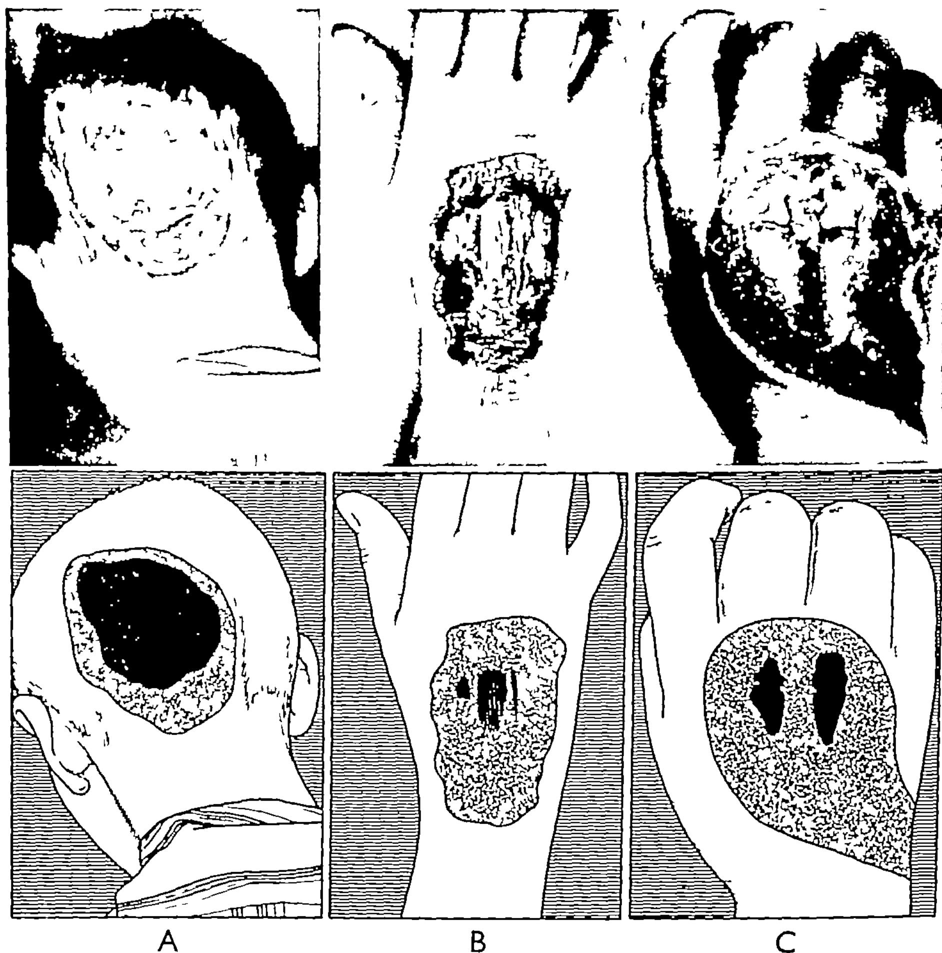


FIG 3, 3

Typical areas—*shown in black*—which will not take a graft successfully

A Bare cortical outer table of skull
B Bare tendon of extensor digitorum
C Bare cortex of metacarpals and proximal phalanges with articular cartilage and open metacarpo-phalangeal joints

The need to have the two surfaces contain the maximum possible number of capillary ends explains the usual practice of removing all fat from the whole skin graft Fat is relatively avascular compared with dermis and would act in effect as a block to the contact of the two vascular surfaces

Methods of physiological fixation involving the use of plasma and thrombin have been described but these have no influence on the take of a graft They are effective only if the principles here stated are followed and if these principles are adhered to they are unnecessary It is true that the early fixation



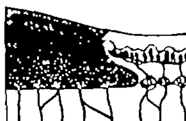






FIG 3 4

The influence of accurate approximation and immobile contact on the vascularisation of a graft

of a graft is by fibrin but both fibrinogen and the enzyme system which converts it to fibrin are already present in ample quantities without requiring to be supplied by the surgeon

Immobilisation. During the phase of capillary outgrowth and link up the graft and its bed must remain completely immobile relative to each other Shearing strains are particularly to be prevented (Fig 3 4) for the best conditions for capillary link up cannot obtain in the presence of such strains and small movements The immobility must in theory be continued until the anchorage of the graft by fibrous tissue is strong enough to take such strains without rupturing the capillaries

In practice other factors may influence the various time intervals at least as far as the initial dressing following grafting is concerned. The whole skin graft is generally slower to vascularise and is usually left for 7–10 days while the split-skin graft is left for 7 days In the case of the split-skin graft on a granulating area this may have to be tempered by the problem of infection and it is usual to dress such a graft on the fourth post-operative day lest accumulation of discharge affect the graft adversely

A further dressing to provide support and immobility is applied thereafter until the graft has consolidated clinically

The factor of pressure

As a result of the teaching of Ferris Smith it is often stated that pressure, preferably at the level of capillary pressure, is necessary to get a graft to take but this is not so provided the conditions already outlined are fulfilled It must be recognised of course that in most circumstances a pressure dressing is the surest way of fulfilling them Nevertheless it is worth stressing that the pressure is merely a means to the end of fulfilling the conditions and has no inherent virtue of its own to justify its use A graft may actually fail because of undue pressure which presumably prevents the normal flow of blood into the graft bed It is in the scalp, face and limbs that such pressure is likely to be attained by circumferential bandaging It is most prone to occur where bone closely underlies a graft and a minimum of soft tissue is present to buffer the pressure Indeed it needs pressure of an order which would produce a sore even in intact skin

The phenomenon of bridging

A graft may take over bare cortical bone, tendon or cartilage, and even if separated from its graft bed by blood clot, provided always that the area is small enough In such circumstances the graft survives by bridging (Fig 3, 5), a phenomenon of particular interest in view of the light which it throws on the process of vascularisation It provides confirmatory evidence of a link-up with the existing vascular network of the graft since bridging could not occur if vascularisation took place by capillary invasion from the graft bed

In most circumstances bridging is strictly limited in area and beyond this necrosis will occur Certainly it cannot be relied on

to cover bone tendon or cartilage successfully Where a very rich vascular network exists both in a graft and its bed however bridging may be possible over a much larger area and the composite free graft of ear skin and cartilage for alar defects succeeds or fails largely on the extent to which bridging is successful

THE WHOLE SKIN GRAFT

The whole skin graft requires optimal conditions to take successfully and so cannot be applied for example to a granulating

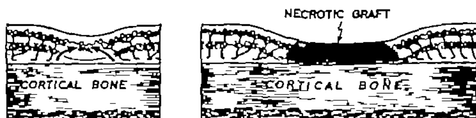


FIG 3.5

The phenomenon of bridging

area A graft of relatively small size only can be used for its donor site must either be closed by suture or covered with a split skin graft These adverse qualities naturally limit its usefulness in practice

Its desirable properties on the other hand make it very much the graft of choice in certain circumstances It does not contract secondarily and this makes it suitable for skin replacement around the mouth and eyelids and on the palmar aspect of hand and fingers It stands pressure well and so is useful on the sole of the foot In the face moreover a whole skin graft from one of the more suitable donor sites described below will give in general the best colour and texture match

Donor Sites

The thickness appearance texture and vascularity of skin vary greatly in different parts of the body and have a strong influence on the selection of the donor site appropriate to a particular surgical situation

Post-auricular skin. The posterior surface of the ear and the adjoining post-auricular hairless mastoid skin (Fig 3, 6) make the best donor site when the face is being grafted The one dis-

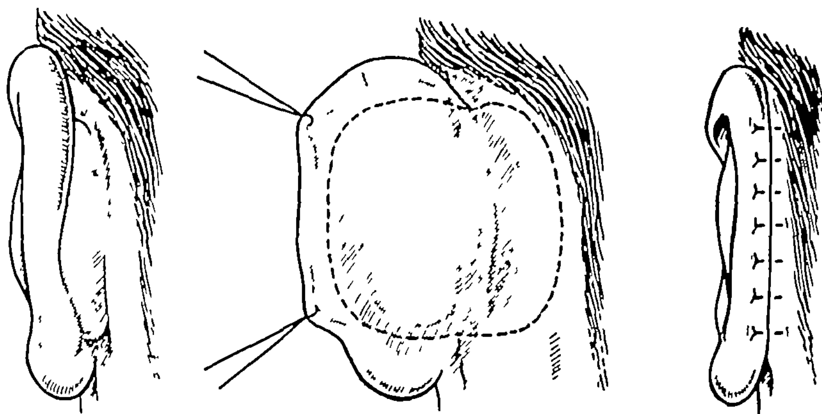


FIG 3, 6

The area available as a source of post-auricular skin and the method of closing the resultant defect

advantage is the limited quantity of skin available and this restricts its use very materially It gives a most excellent skin colour and texture match (Fig 3, 7) and when replacing eyelid skin is often

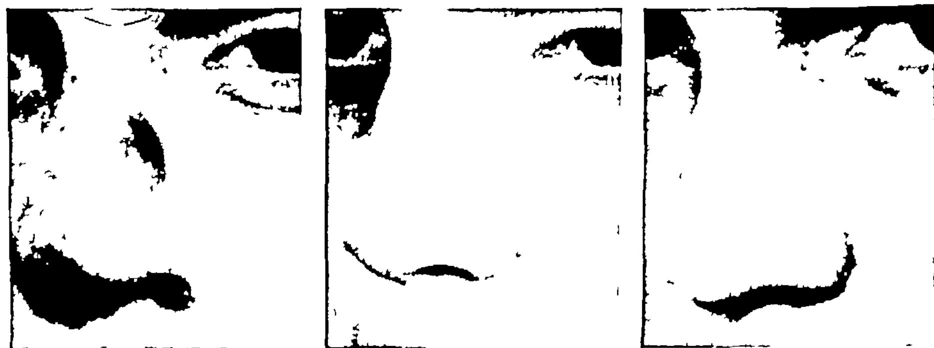


FIG 3, 7

The early and late appearance of a post-auricular full thickness graft applied to the nose following the excision of a simple pigmented naevus

virtually undetectable The vascularity both of the graft and the sites to which it is usually applied make it the easiest of whole skin grafts to get to take The donor site is closed by direct suture

The post-auricular whole skin graft has its main use in repairing small defects of the face and the area of skin available behind the ear alone limits the size of the defect which it can be used to cover

Supraclavicular skin The skin of the lower posterior triangle of the neck (Fig 3, 8) gives a good colour and texture match used on the face though one distinctly inferior to post auricular skin A larger area of skin is available but the increase is too small to make it more obviously useful as the donor area itself must be grafted in most instances This adds a cosmetic defect of its own and one which is likely to be particularly undesirable in the female



Fig 3 8

The late appearance of a supraclavicular full thickness graft applied to the face following excision of a hairy naevus The supraclavicular defect was covered with a dermatome split-skin graft from abdomen

Its usefulness is thus rather restricted and it is not often needed It might be considered for a defect just too large for a post-auricular whole skin graft where a rotation flap is contra indicated

Flexural skin. The antecubital fossa and the groin are both possible donor sites The dermis is thin and the skin mobile on the deeper tissues Applied to the face the cosmetic result is not greatly inferior to that using supraclavicular skin Only a limited quantity is available unless a secondary graft is used to cover the donor site

In the antecubital fossa the donor site is more often exposed

and the scarring of closure consequently more of a drawback Furthermore, if much tension is used in closing it by direct suture a hypertrophic scar or keloid may develop In the groin the pubic hair may limit both the use and quantity available but the area is valuable if a long narrow graft is needed, for closure in such circumstances is relatively simple

The groin is more generally useful and for the hand it provides a good source of skin

Thigh and abdominal skin. The texture and colour match of thigh and abdominal skin grafted to the face is usually poor The skin either stays extremely pale or becomes hyperpigmented relative to the rest of the face An added defect is a loss of the constantly varying fine play of normal facial expression The grafted area has instead a rather mask-like appearance due possibly to its thicker dermis Although a thick split-skin graft cut from the abdomen with the drum dermatome tends to be used rather than a whole skin graft for replacing extensive areas of facial skin loss it shares the defects of the whole skin graft

Both sites provide a good source of skin for the palm of the hand and the thick dermis gives a good pad to take the necessary pressure used on the sole of the foot If a graft of any size is used the donor site must in its turn be grafted and even when the donor site can be directly sutured the scar usually stretches badly

Method of Use

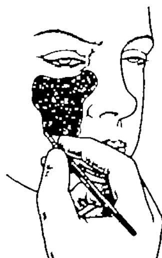
The whole skin graft is accurately fitted to the defect and so a pattern of the defect to be grafted must be made to have the graft at normal skin tension in its new site Aluminium foil, jaconet, and oil silk are all useful materials for making patterns Around the eyelids aluminium foil is probably best, elsewhere the others are more satisfactory

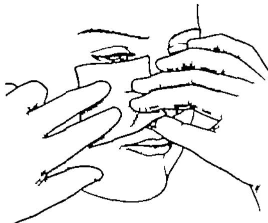
The graft will be used under two different conditions which influence the method used to make the pattern

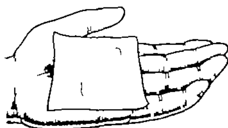
Where the area and contour of the defect are accurately known beforehand, e g when removing a naevus, it is best to mark out the area of excision and make the pattern of this outline This avoids having to make a pattern of the post-excisional defect which would be too big because of wound retraction or of the

pathological specimen after removal which would be too small for the same reason

An outline of the shape can be made easily making use of the solubility of Bonney's Blue in spirit (Fig 3, 9) A sheet of jaconet







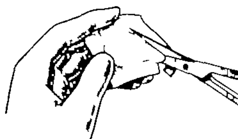


Fig 3 9

The making of a jaconet pattern of the outline of a lesion prior to its excision

moistened on the fabric surface with spirit and pressed on the lesion outlined with the dye lifts enough colour to leave a good imprint of the outline on the fabric

When the area is irregular it is wise to orientate the graft before cutting with multiple dye tattoo punctures (Fig 3, 10) to fit corresponding marks in the skin surrounding the defect to be grafted Failure to do this can make the fitting of the graft unnecessarily difficult

and the scarring of closure consequently more of a drawback Furthermore, if much tension is used in closing it by direct suture a hypertrophic scar or keloid may develop In the groin the pubic hair may limit both the use and quantity available but the area is valuable if a long narrow graft is needed, for closure in such circumstances is relatively simple

The groin is more generally useful and for the hand it provides a good source of skin

Thigh and abdominal skin. The texture and colour match of thigh and abdominal skin grafted to the face is usually poor The skin either stays extremely pale or becomes hyperpigmented relative to the rest of the face An added defect is a loss of the constantly varying fine play of normal facial expression The grafted area has instead a rather mask-like appearance due possibly to its thicker dermis Although a thick split-skin graft cut from the abdomen with the drum dermatome tends to be used rather than a whole skin graft for replacing extensive areas of facial skin loss it shares the defects of the whole skin graft

Both sites provide a good source of skin for the palm of the hand and the thick dermis gives a good pad to take the necessary pressure used on the sole of the foot If a graft of any size is used the donor site must in its turn be grafted and even when the donor site can be directly sutured the scar usually stretches badly

Method of Use

The whole skin graft is accurately fitted to the defect and so a pattern of the defect to be grafted must be made to have the graft at normal skin tension in its new site Aluminium foil, jaconet, and oil silk are all useful materials for making patterns Around the eyelids aluminium foil is probably best, elsewhere the others are more satisfactory

The graft will be used under two different conditions which influence the method used to make the pattern

Where the area and contour of the defect are accurately known beforehand, e g when removing a naevus, it is best to mark out the area of excision and make the pattern of this outline This avoids having to make a pattern of the post-excisional defect which would be too big because of wound retraction or of the

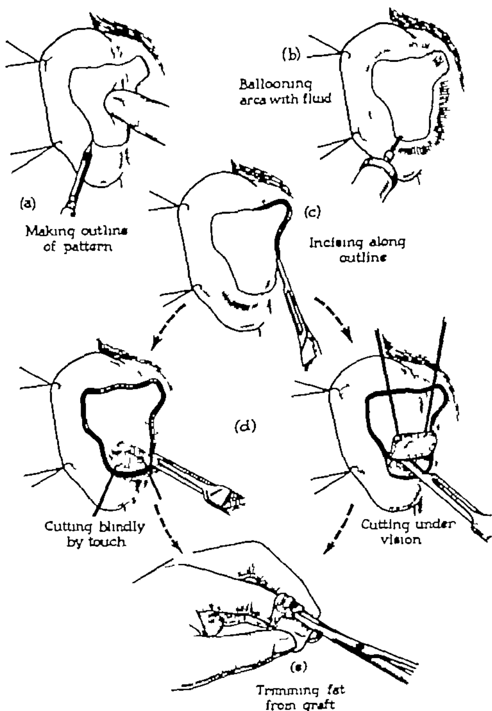


FIG 3, 11
The method of cutting a full thickness graft

Where the defect is not known beforehand, e g following excision of a malignant lesion, or release of a contracture, the pattern can only be made once the defect has been surgically created In those circumstances the defect should be displayed

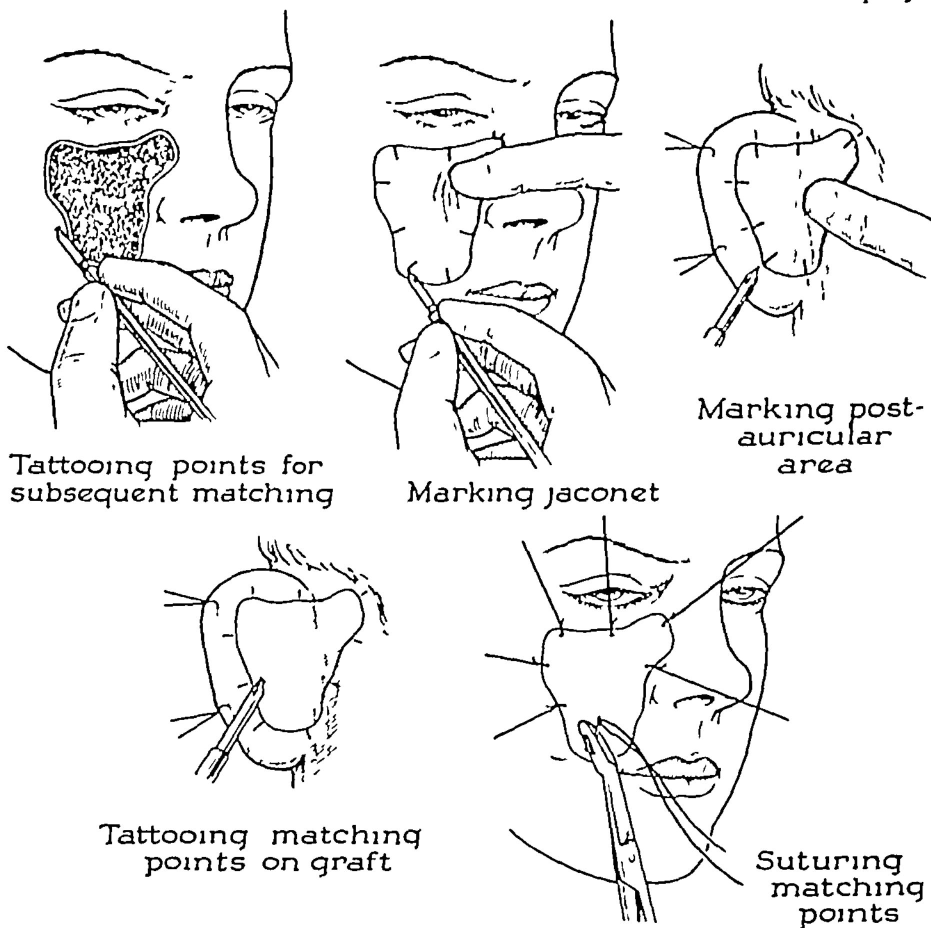


FIG 3, 10

The tattooing of matching points to facilitate orientation of the graft for suturing

to the full before making the pattern This applies with particular force to the eyelid where failure to make the pattern and subsequently the graft of a size to fill the defect in full will result in residual ectropion

Cutting the Graft

In cutting a whole skin graft (Fig 3, 11) time and care can be spent at the actual time of cutting so that no fat is left on the graft,

Donor Sites

These are selected in any set instance by such factors as the amount of skin required whether a good colour and texture match is needed local convenience as in grafting from forearm to hand with need for only one dressing the necessity of having no hair on the graft the cutting instrument available the desirability where possible of avoiding the leg in the aged or out patient

The usual areas are

Virtually the whole of the reasonably plane surface of the torso
The thigh and upper arm
The flexor aspect of forearm

When these are not available or all possible sites are needed skin can also be cut from

The other aspects of forearm
The lower leg

Graft-cutting Instruments

The instruments commonly used for cutting grafts are

The Humby knife which was developed from and has now largely replaced the Blair knife
The drum dermatome
The electric dermatome

The Humby and Blair knives (Fig 3, 12)

The Humby knife is similar to the Blair knife with the refinement of an adjustable roller which controls the thickness of the graft cut It is the most frequently used instrument for routine graft cutting despite the fact that both it and the Blair knife can only be used on convex surfaces The technique of cutting with it is readily acquired and for the surgeon who cuts only an occasional graft it is much the better instrument of the two

The Blair knife is something of a virtuoso instrument It is much more difficult to use and when a large graft is being cut, consistently correct thickness is a real achievement for most surgeons With the advent of the Humby knife it is seldom used

or the graft may be cut without special regard to fat, the fat being subsequently removed with scissors Excision of the fat after the graft has been cut is a tedious business but to cut the graft without fat requires both skill and care It is probably easier for the surgeon who seldom uses the method not to attempt it lest the graft be buttonholed in the process Most surgeons gradually acquire a feel for the correct plane at the time of cutting the graft

A useful device, especially in the concavity behind the ear, is to balloon the whole area with fluid Using the pattern already made the outline is marked on the skin with Bonney's Blue, incised and undercut It often helps to pull the skin of the graft taut over the knife with hooks so that the knife is cutting blindly, largely by touch Alternatively, the graft can be held turned back so that cutting is done under vision Oddly enough this method is less precise and usually results in more fat being left on the graft Any fat left on the graft must be carefully removed with scissors

Care of the Donor Site

Behind the ear, closure by direct suture is usually feasible Elsewhere direct suture should be used where possible In the thigh and abdomen, where the superficial fascia is relatively fixed, the exposed fascia is best excised to facilitate closure In the flexures, where the skin is much more mobile, this is less often necessary Where the donor site defect is too large to suture a split-skin graft must be used to cover it

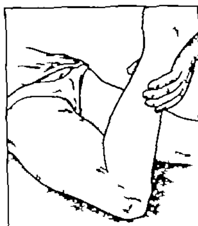
THE SPLIT-SKIN GRAFT

A split-skin graft may vary in thickness from what is virtually a whole skin graft to one which is almost epidermal and each has its place depending on which property of the particular thickness is wanted It is used either as temporary cover to provide healing, e g in burns, in the immediate post-excision treatment of skin malignancies, in the coverage of bridge pedicle defects, or as permanent cover In general temporary grafts are cut thinner than permanent grafts but not infrequently a graft meant for temporary cover proves entirely acceptable as permanent cover

Because of the prominence of the femoral shaft the **anterior aspect** does not give a broad plane surface and it is not used unless all donor sites are needed



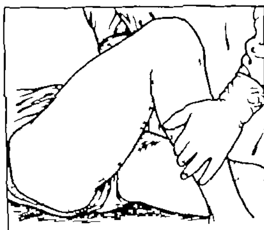
Thigh—*medial aspect*



Thigh—*posterior aspect (patient prone)*



Thigh—*posterior aspect (patient lying on back)*



Thigh—*lateral aspect*

FIG 3, 13

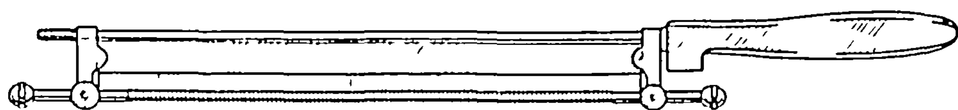
Positioning the thigh for cutting a graft

In the **arm** (Fig 3, 14) positioning and pressure are used in the same way to give the broadest plane surface

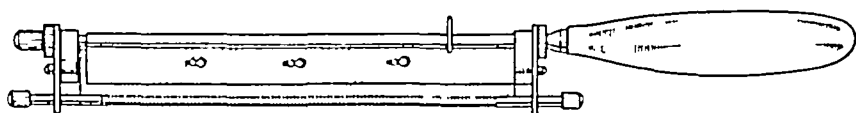
Preparing the knife Ideally the blade when cutting moves to and fro smoothly over the skin surface which does not move at all with the knife Drag which is the result of friction between blade and skin causes the skin to oscillate to and fro with the

Placing the donor site. The donor site most often used is the thigh and the positioning of the leg for this purpose will be described in detail (Fig 3, 13) but the principles outlined can be applied to any other donor site

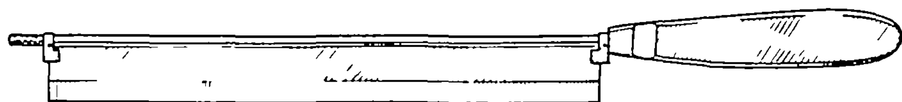
The leg is placed with the appropriate group of muscles relaxed so that by pressing the muscle group either medially or laterally the maximum of plane surface is presented to the knife



Humby Knife (*Bodenham modification*)



Humby Knife (*Braithwaite pattern*)



Blair Knife (*Bodenham modification*)

FIG 3, 12

The Humby and Blair knives

For the **medial side of thigh** the leg is placed as in Fig 3, 13 The assistant presses from below with the flat of both hands pushing round the hamstrings and adductors to give the necessary wide flat surface for cutting a broad graft

When the **lateral aspect** is used (Fig 3, 13) the surface produced when the assistant presses laterally is less satisfactorily flat than the medial aspect especially in its lower part because of the tautness of the ilio-tibial band The depression which it produces between the vastus lateralis and the biceps femoris becomes less noticeable proximally

For the **posterior aspect** (Fig 3, 13) flexion of both hip and knee are needed to get at the surface unless the subject is prone Distally the ridges produced by the diverging hamstrings make a good graft difficult to obtain but passing proximally the flat surface broadens and a good graft can be cut readily

which is thin and only partly supported As a result the adjustment markings present on the knife give a setting which tends to vary with different blades and reliance on the markings alone in setting the roller will give inconsistency of graft thickness

By holding the knife up to the light the actual clearance between blade and roller can be seen and this method gives a more reliable reading Although the surgeon learns with experience to set the knife by eye a clearance of a little less than ¼ mm as a rule will be found to give a graft of average thickness It must be emphasised however that this must in turn be controlled by watching both the graft as it is cut and the bed from which it is being cut The guiding characters of thickness are described below

Cutting the graft The surgeon should work from the more convenient side of the patient cutting down the limb or up according to his position

A little in front of the knife and moving smoothly at a fixed distance from it a wooden board is held pressed hard down on the skin (Fig 3, 15) The board serves the double purpose of steadying and flattening the skin as the blade reaches it The edge of the board which is pressing on the skin is lubricated with petroleum jelly so that it moves smoothly with the knife To get knife and board moving smoothly forward in unison takes practice

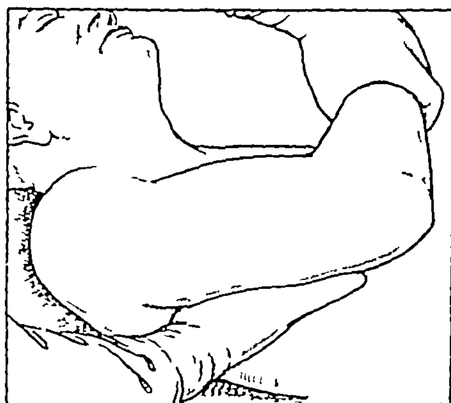
With both Blair and Humby knife the secret of good cutting is to concentrate on an even to and fro motion rather than on the forward moving of the knife as it cuts the graft

It may help to make the whole skin area as taut as possible by having a further assistant hold the skin steady and tight with a wooden board just behind the knife before it starts to cut The board is kept still as the knife moves forward to cut the graft Where the skin is atrophic lax and mobile as in the aged or emaciated subject this manoeuvre is useful insofar as it helps to eliminate drag

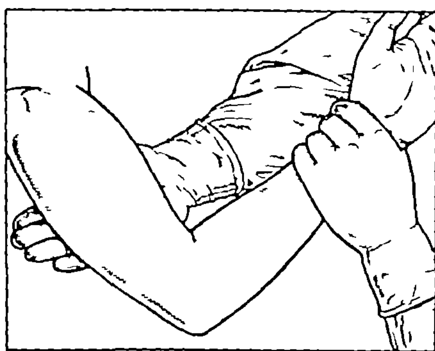
A further difficulty in the use of the Humby knife is a tendency for the clearance between roller and blade to increase as the graft is being cut so that the graft becomes steadily thicker This must always be watched for so that the roller can be re adjusted to its original setting

Assessment of thickness Although a setting of the roller has been suggested above the surgeon must be prepared to modify it

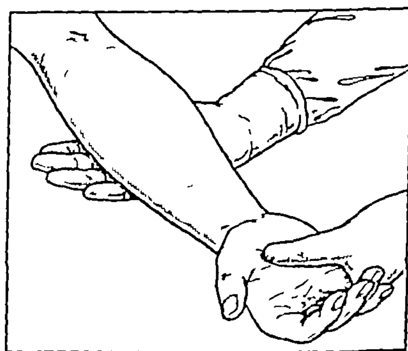
knife and makes the graft more difficult to cut It cannot be completely eliminated but lubrication does help to reduce it The usual lubricant is petroleum jelly and the surface of the blade next the skin should be smeared with it When the Humby knife is used the lubricant must be kept clear of the roller lest the



Arm —— *lateral aspect*



Arm —— *medial aspect*



Forearm —— *flexor surface*

FIG 3, 14

Positioning the arm for cutting a graft

graft instead of gathering on the blade as it passes between blade and roller should stick to the roller, winding itself around it

Setting the knife. Setting the knife is necessary only with the Humby knife where graft thickness is controlled by adjusting the distance between roller and blade The advantage of the interchangeable blade which is now almost universal is that it gives a much cleaner cut with minimal drag from bluntness, but this is to some extent offset by the slight lack of rigidity of the blade

which is thin and only partly supported As a result the adjustment markings present on the knife give a setting which tends to vary with different blades and reliance on the markings alone in setting the roller will give inconsistency of graft thickness

By holding the knife up to the light the actual clearance between blade and roller can be seen and this method gives a more reliable reading Although the surgeon learns with experience to set the knife by eye a clearance of a little less than $\frac{1}{2}$ mm as a rule will be found to give a graft of average thickness It must be emphasised however that this must in turn be controlled by watching both the graft as it is cut and the bed from which it is being cut The guiding characters of thickness are described below

Cutting the graft. The surgeon should work from the more convenient side of the patient cutting down the limb or up according to his position

A little in front of the knife and moving smoothly at a fixed distance from it a wooden board is held pressed hard down on the skin (Fig 3, 15) The board serves the double purpose of steadying and flattening the skin as the blade reaches it The edge of the board which is pressing on the skin is lubricated with petroleum jelly so that it moves smoothly with the knife To get knife and board moving smoothly forward in unison takes practice

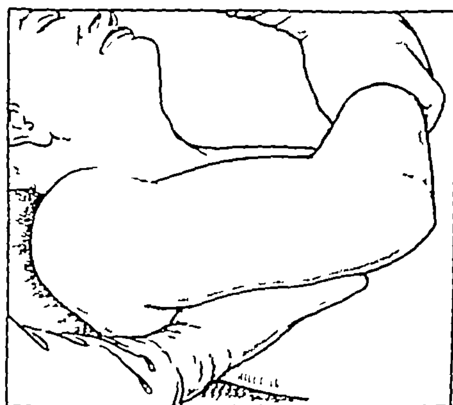
With both Blair and Humby knife the secret of good cutting is to concentrate on an even to and fro motion rather than on the forward moving of the knife as it cuts the graft

It may help to make the whole skin area as taut as possible by having a further assistant hold the skin steady and tight with a wooden board just behind the knife before it starts to cut The board is kept still as the knife moves forward to cut the graft Where the skin is atrophic lax and mobile as in the aged or emaciated subject this manoeuvre is useful insofar as it helps to eliminate drag

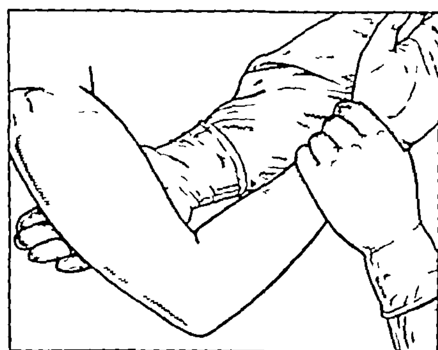
A further difficulty in the use of the Humby knife is a tendency for the clearance between roller and blade to increase as the graft is being cut so that the graft becomes steadily thicker This must always be watched for so that the roller can be re adjusted to its original setting

Assessment of thickness Although a setting of the roller has been suggested above the surgeon must be prepared to modify it

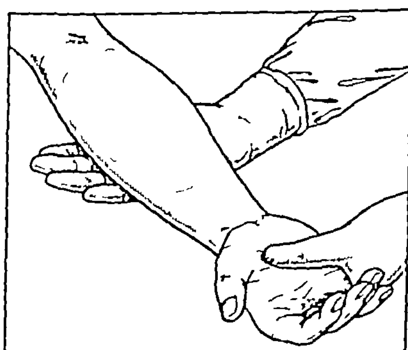
knife and makes the graft more difficult to cut It cannot be completely eliminated but lubrication does help to reduce it The usual lubricant is petroleum jelly and the surface of the blade next the skin should be smeared with it When the Humby knife is used the lubricant must be kept clear of the roller lest the



Arm —— *lateral aspect*



Arm —— *medial aspect*



Forearm —— *flexor surface*

FIG 3, 14

Positioning the arm for cutting a graft

graft instead of gathering on the blade as it passes between blade and roller should stick to the roller, winding itself around it

Setting the knife. Setting the knife is necessary only with the Humby knife where graft thickness is controlled by adjusting the distance between roller and blade The advantage of the interchangeable blade which is now almost universal is that it gives a much cleaner cut with minimal drag from bluntness, but this is to some extent offset by the slight lack of rigidity of the blade



FIG 3, 16

The translucency of different thicknesses of split-skin graft
A Thin B Medium C Thick



FIG 3 17

The pattern of bleeding of the dono sites of different thicknesses of split-skin graft
A Thin B Medium C Thick

if necessary. The first ¼ inch or so of the graft cut gives a good indication of the thickness and the setting can be adjusted accordingly

The *translucency of the graft* is the main index of thickness (Fig 3, 16) The very thin graft is translucent and not unlike

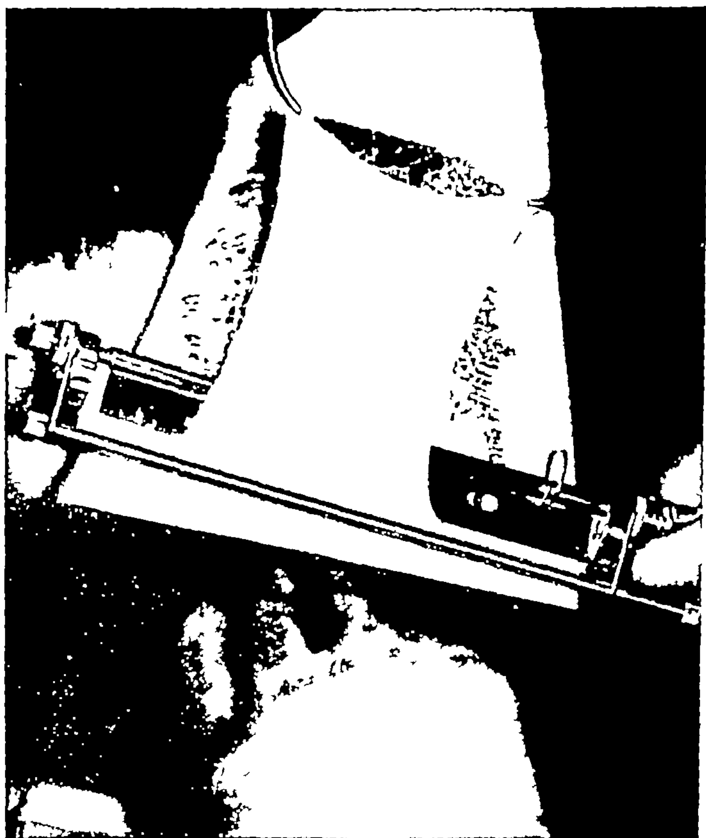


Fig 3, 15

Cutting a graft with the Humby knife

tissue paper, the grey of the knife blade shows easily through Thicker grafts are increasingly opaque until the whole skin graft has the colour and appearance of cadaver skin A split-skin graft of intermediate thickness is moderately translucent

The *pattern of bleeding of the donor site* gives a further indication of thickness (Fig 3, 17) The thin graft produces a high density of tiny bleeding points, the thicker graft gives a lower density of larger points

While these criteria are generally applicable they should always

drum for cutting by the knife blade which is moved to and fro parallel to the axis of the drum at a previously adjusted fixed

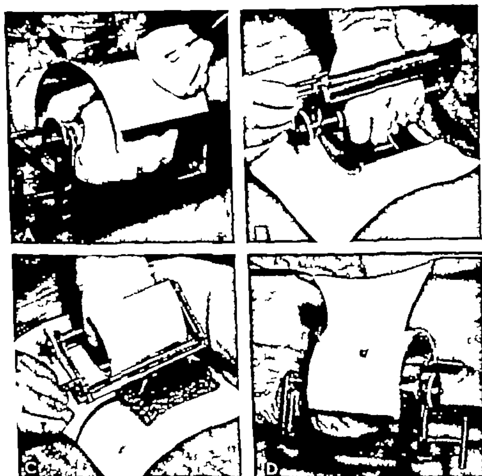


FIG 3, 18

The drum dermatome and its use

A Painting the drum with adhesive
B Lifting the skin with the drum before beginning to cut the graft
C Cutting the graft
D Stripping the graft from the drum

clearance distance As cutting proceeds the graft is left adhering to the drum (Fig 3 18)

Cutting a graft with the dermatome can only be learned by demonstration and practice and it is not proposed to discuss the technique in any detail There are some hints however which may help the beginner

be correlated with the initial appearance of the skin in the individual patient particularly as to the presence of clinical atrophy With the papery skin of the aged the graft must be correspondingly thin and the distribution of bleeding points gives no help in such cases

The thickness of the skin also seems to vary in various parts of the limb, in general lateral is thicker than medial and distal thicker than proximal in the individual, but individual variation is considerable

The drum dermatome

In Great Britain the model generally used is the Padgett-Hood or one of its modifications (Fig 3, 18) Its clumsiness and uncertainty in use compared with the Humby knife have prevented it from achieving great popularity for routine purposes An added defect is that successive drums of skin are not readily cut without meticulous cleansing and fresh preparation of both dermatome and skin None of these criticisms apply to the Reese *dermatome which is currently popular in the* United States and which is a much superior instrument It is unfortunately not manufactured in this country The description which follows refers only to the Padgett-Hood instrument or its modifications and not the Reese dermatome

Although the drum dermatome is not used routinely there are occasions where its use is particularly indicated The precise indications naturally depend to some extent on the relative skill of the operator with dermatome and grafting knife but in most cases the Humby knife is preferred unless there is a positive reason for using the dermatome In the extensive deep burn where all donor areas are needed the dermatome may have to be used since at least until the advent of the electric dermatome it alone could cut from abdomen, chest and much of back On the credit side the dermatome graft is recognisably *uniform in thickness* and this gives it a cosmetic advantage over skin cut with the Humby knife when the face is being grafted It is in providing extensive skin cover for the face that the dermatome graft finds its main use and in those circumstances a thick split-skin graft is used

In using the dermatome the drum and donor area are painted with an adhesive compound When the drum is pressed against the skin the two surfaces adhere and the skin can be lifted with the

drum for cutting by the knife blade which is moved to and fro parallel to the axis of the drum at a previously adjusted fixed

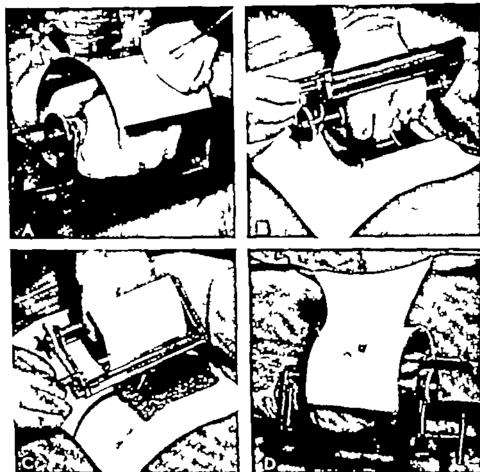


FIG 3, 18

The drum dermatome and its use

A Painting the drum with adhesive
B Lifting the skin with the drum before beginning to cut the graft
C Cutting the graft
D Stripping the graft from the drum

clearance distance As cutting proceeds the graft is left adhering to the drum (Fig 3 18)

Cutting a graft with the dermatome can only be learned by demonstration and practice and it is not proposed to discuss the technique in any detail There are some hints however which may help the beginner

Graft thickness. Most instruments have a gauge which determines thickness A graft of medium thickness is 12–14/1,000 inch, but thicknesses from 8 or even less up to 16 or 18 can be used according to need As with the Humby knife the gauge reading is not always accurate and it should always be matched against the graft actually cut It is often difficult to see the graft well early on in the cut but almost as good an indication is the density and size of the bleeding points of the donor area A thick graft is technically easier to cut than a thin one When lobules of fat appear the graft is in effect of whole skin graft thickness

Lacquering the surfaces. Both drum and skin should be given a thorough preliminary cleansing with ether to remove all grease so that the lacquer will stick properly Smooth application of the lacquer helps it to dry uniformly The edges of the drum take the greatest pull when the dermatome is cutting and should be carefully lacquered Being colder than the skin as a rule the drum dries more slowly but patience in waiting until the surfaces are quite dry pays dividends

Lubrication Both the surface of the knife moving against the skin and the axle of the drum should be smeared with petroleum jelly to help the knife to move smoothly to and fro Lubricant must not get on to either of the lacquered surfaces or complete loss of stickiness will result

Cutting the graft. A good initial cut of the knife blade usually means a good graft and care with the first cut is worth while, making sure especially that the skin is sticking from side to side of the drum Just how far the drum can safely be raised to pull up the skin for cutting depends on the laxity of the skin Raising the drum too little allows the knife to plough deeply into the skin beyond the side of the drum and an assistant should be ready to depress the skin here with a suitable instrument Raising the drum too far increases the tension unduly and is liable to tear the skin from the drum so that the knife cannot cut properly and this produces a patchy, incomplete drum of skin The middle course is only acquired with experience as is the co-ordinated to and fro cutting of the knife and forward rolling of the drum

Removing the skin from the drum The

largely on the graft and as it is taken from the drum its stickiness must be removed With mosquito forceps on each corner to elevate the margin of the graft an ether swab will remove the lacquer as the graft comes off the drum This method is effective but messy and a cleaner way is to spray the graft coming off the drum with either penicillin or sulpha powder The lacquer remains on the graft but has lost its stickiness

The problem of residual lacquer on the graft has largely been solved recently by using EVO STIK IMPACT household adhesive This contact adhesive can readily be diluted to a viscosity suitable for application to drum and skin by adding an equal volume of ether and stirring until the two liquids are well mixed As an adhesive it is much better than any the author has previously used and it has the added advantage of bonding to the drum even more strongly than to the skin so that the graft strips off the drum completely clean leaving the adhesive entirely on the drum

The electric dermatome

Although this instrument has been in use in the United States for some time it has only recently become widely available in this country One of its major disadvantages is that it is at once a complex and fragile instrument It does not stand rough handling and if anything goes wrong it has to go back to the maker with all the annoyance and delay which this entails With it much of the skill has gone from graft cutting and if the instructions are carefully followed the surgeon can scarcely fail to cut a graft successfully It has the great merit too of cutting a graft of controlled width and accurately controllable thickness from almost any part of trunk or limbs and readily cuts a very thin graft—a thing that other instruments do less successfully Its maximum width is less than either the Humby knife or drum dermatome and with the more recent models available in this country the width of graft cut can be narrowed at will a refinement already present in the United States model

In appearance it is not unlike a large hair-cutting machine (Fig 3 19) and the resemblance is maintained in action with the rapidly oscillating cutting blade which is driven either electrically or by compressed air The skin is held steady and lubricated

Graft thickness. Most instruments have a gauge which determines thickness A graft of medium thickness is 12-14/1,000 inch, but thicknesses from 8 or even less up to 16 or 18 can be used according to need As with the Humby knife the gauge reading is not always accurate and it should always be matched against the graft actually cut It is often difficult to see the graft well early on in the cut but almost as good an indication is the density and size of the bleeding points of the donor area A thick graft is technically easier to cut than a thin one When lobules of fat appear the graft is in effect of whole skin graft thickness

Lacquering the surfaces. Both drum and skin should be given a thorough preliminary cleansing with ether to remove all grease so that the lacquer will stick properly Smooth application of the lacquer helps it to dry uniformly The edges of the drum take the greatest pull when the dermatome is cutting and should be carefully lacquered Being colder than the skin as a rule the drum dries more slowly but patience in waiting until the surfaces are quite dry pays dividends

Lubrication. Both the surface of the knife moving against the skin and the axle of the drum should be smeared with petroleum jelly to help the knife to move smoothly to and fro Lubricant must not get on to either of the lacquered surfaces or complete loss of stickiness will result

Cutting the graft. A good initial cut of the knife blade usually means a good graft and care with the first cut is worth while, making sure especially that the skin is sticking from side to side of the drum Just how far the drum can safely be raised to pull up the skin for cutting depends on the laxity of the skin Raising the drum too little allows the knife to plough deeply into the skin beyond the side of the drum and an assistant should be ready to depress the skin here with a suitable instrument Raising the drum too far increases the tension unduly and is liable to tear the skin from the drum so that the knife cannot cut properly and this produces a patchy, incomplete drum of skin The middle course is only acquired with experience as is the co-ordinated to and fro cutting of the knife and forward rolling of the drum

Removing the skin from the drum. The

split skin grafts have been cut The donor site of the thin graft on the one hand with its full complement of cut hair follicles heals rapidly within 10 days while the donor site of the thick graft on the other hand depending entirely on sweat gland remnants heals much more slowly taking 21 days or more Most grafts are of intermediate thickness and leave a percentage of follicles

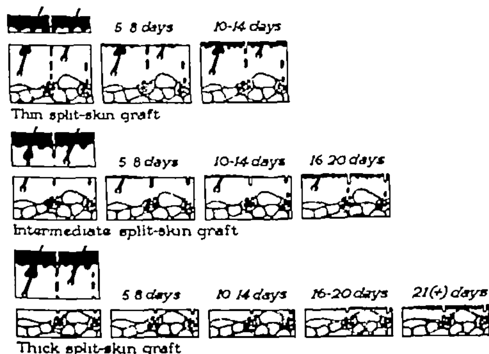


FIG 3, 20

The healing of the donor sites of the various thicknesses of split-skin graft.

so that healing takes 10–21 days A donor area only granulates if no follicles or sweat glands remain and in such circumstances healing must take place from the margin of the area

It will be seen from this that the healing of a donor area is analogous to that of a superficial burn

Care of the Donor Area

The main difficulty in treating a donor site arises from the fact that the dressing becomes extremely hard and sticks like glue to the skin so that its removal causes bleeding and considerable pain as the regenerating epithelium is torn off Usual practice

with liquid paraffin so that the instrument can move forward smoothly

It is in the grafting of the extensive deep burn that the electric dermatome has been a very real advance Its ability to cut skin from almost any part of the body surface has greatly extended the available donor areas The straight margin and uniform thickness of the graft which it cuts mean that a limb can be completely

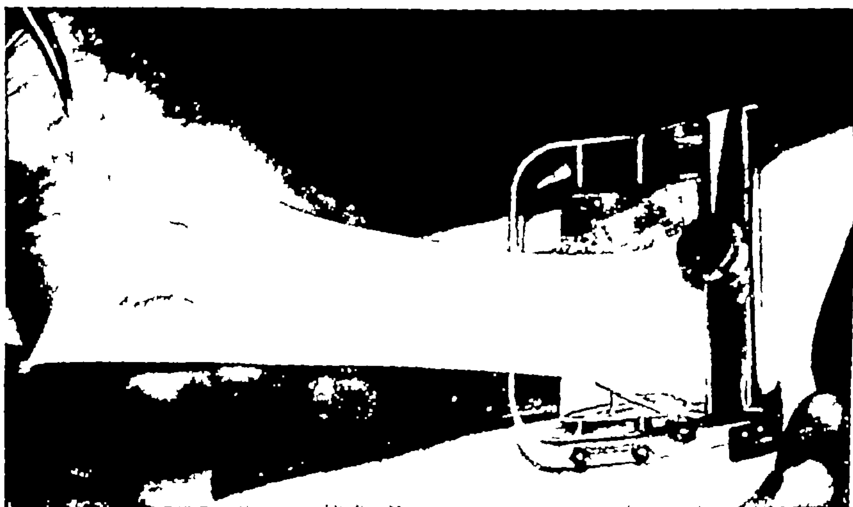


FIG 3, 19

Cutting a very thin split-skin graft with the electric dermatome

flayed with scarcely any wastage of skin between adjoining graft sites in the knowledge that the whole donor area will heal uniformly and rapidly It becomes a practical possibility as a result to cut successive crops of skin from the same donor site, a most valuable property when skin is at a premium

Healing of the Donor Area (Fig 3, 20)

In the donor site of a split-skin graft greater or lesser portions of the pilo-sebaceous follicles and sweat glands remain, and from these multiple foci epithelium spreads until the area is covered with skin The pilo-sebaceous follicles are much more active as centres of epithelial regeneration than the sweat glands which react more sluggishly Anatomically the sweat glands extend more deeply than the hair follicles and this is reflected in the different healing patterns of sites from which thin and thick

is a weaker constrictor of cutaneous vessels than adrenaline but it is less likely to give rise to side effects after absorption Considerable variation in recommended concentrations are described but in the large volumes often required in plastic surgery concentrations of 1–2 parts in 200 000 of saline are safe and in practice effective

Ligature of obvious bleeding points The forceps must pick up only the actual point so that the necrosis caused by the short fine cat gut tie is minimal It has been taught that the graft will not take over cat gut but this is not so unless coarse massive ligatures are used The diathermy is a possible alternative but against it the same argument can be advanced as against cat gut In practice take is not significantly reduced if the block of tissue killed by either method is small enough

Local adrenaline If the tissue excised has not already been infiltrated local adrenaline or noradrenaline will reduce capillary ooze

Use of time Without doubt time is the most important single factor in haemostasis The steps of the operation should be planned to give the recipient area the longest possible time for the normal haemostatic processes to become effective While waiting for bleeding to cease the area may be left covered with gauze soaked in saline or adrenaline or alternatively it may be irrigated with adrenaline solution and then left exposed What must be avoided is constant dabbing and swabbing which only serve to encourage oozing

Use and misuse of the sucker The sucker can play a most valuable part during an excision in allowing the surgeon to see precisely where he is cutting The defect once created however suction applied to the raw area will only keep bleeding going If a specific clot has to be sucked off the sucker nozzle should never actually touch the tissue or the bleeder will surely begin again

When the graft has been sutured in position and the dressing is ready some surgeons suck out any clots which have formed during suturing While this is not ineffective the dressing must be applied without delay for bleeding usually begins again as a result of the trauma of the suction

Marginal bleeders For these a ligature is seldom needed With appropriate placing the graft suture can be made to serve the double purpose of haemostasis and graft anchorage

is to leave the dressing quite alone until it separates spontaneously or, failing this, to soak it off Such masterly inactivity is only possible if the dressing remains dry When part of the graft has been thicker the corresponding segment of donor area heals less rapidly and may even granulate with resulting discharge It has then to be treated as a granulating wound If small in area it will heal spontaneously, but if of any size it should be grafted without delay

A useful prophylactic where all or part of a donor area looks at all doubtful from a depth point of view and particularly if fat is showing to any extent is to cover it with a thin split-skin graft when the initial graft is cut Some surgeons practise routine grafting of all abdominal dermatome graft donor areas Such a practice of course buries some sweat gland and hair follicle remnants and these do tend to form small cysts but such cysts usually rupture at the surface without giving trouble and this drawback is largely a theoretical one

THE RECIPIENT AREA

Free skin grafts are applied either to raw surfaces surgically created or at least surgically clean, or to granulating wounds The practice of grafting varies with the two types of surface

The Surgically Clean Surface

Preparing the recipient area

Although a whole skin graft or split-skin graft may be used according to circumstance the underlying principle does not vary A level surface is always desirable for irregularities are likely to give rise to tenting of the graft across the hollow unless it is shallow The common reason for failure of a graft where it might reasonably be expected to take well is **haematoma** and a completely dry field is essential before the graft is applied To this end several measures can be used

Infiltration of the area prior to excision Bleeding can be reduced by injecting a vaso-constricting fluid into the tissue to be excised The fluid usually used is local anaesthetic with adrenaline but as some of the local anaesthetics are vaso-dilators it is preferable in the generally anaesthetised patient to use saline as the diluent Either adrenaline or noradrenaline can be used Noradrenaline

few particulars The sutures which fix the graft in position around its margin are left long and tied over a plug of cotton wool which acts as a combined pressure and immobilising dressing In this role it is reinforced by further dressings—gauze cotton wool and crepe bandages or elastoplast

The whole skin graft. Cut to its prescribed pattern the whole skin graft is intended to fit the defect accurately and so is carefully

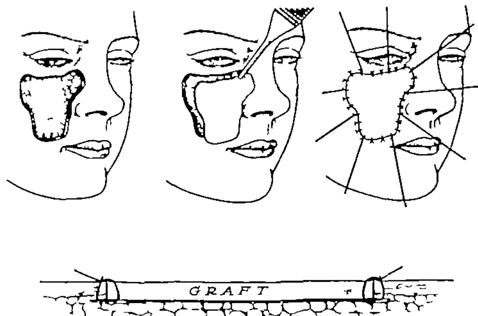
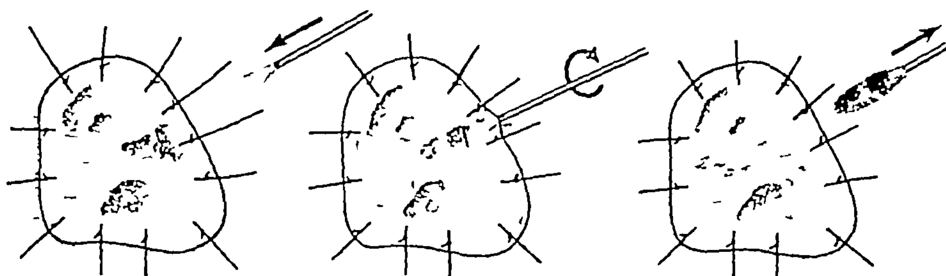


FIG 3, 22
The application and suturing of a full thickness skin graft

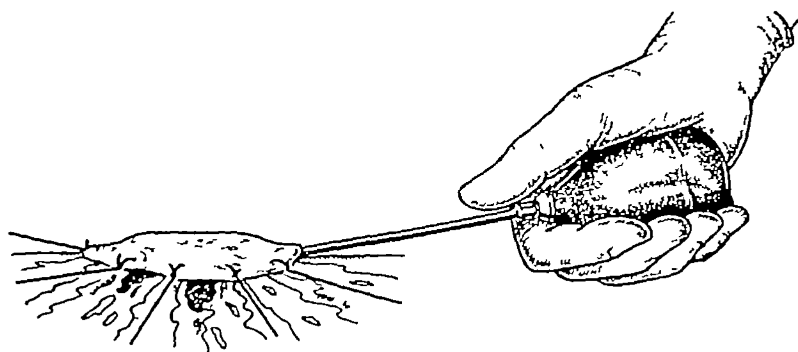
sutured edge to edge along its margin (Fig 3, 22) Enough sutures must be inserted to give as accurate an edge apposition as would be demanded in the suture of an incision and just as in wound suture care must be taken to avoid inversion of the edges Only sufficient sutures are left long to provide a snug tie over the remainder are cut short

The split skin graft (Fig 3, 23) The tendency of the split skin graft to contract subsequently makes it advisable to display the raw area to the full so that as much skin can be inserted as the defect is capable of taking Such a graft is not usually spread on tulle gras before being applied to the raw area though the added rigidity which the tulle gras backing provides sometimes does make handling of the graft technically easier

Chip syringe and orange stick (Fig 3, 21) Unless the graft bed is absolutely dry it is wise to flush out the whole site with saline once the graft is sutured in place using a chip syringe or a 20 ml syringe with blunt cannula Any small remaining clot can be removed by inserting an orange stick tipped with cotton wool



Use of orange stick to remove blood clots



Removal of blood clots by irrigation with chip syringe

FIG 3, 21

Removal of blood clots from under a graft with an orange stick and by irrigation

When the stick is twirled the clot is caught by the wool and can be removed with the stick

Plasma and thrombin Some surgeons use this to wash under the graft as a final measure just before applying the dressing so that the resulting clot will anchor the graft As already indicated the procedure has no theoretical basis Its ritual use has been generally abandoned with consequent simplification of grafting procedure and no change in results

Applying the graft

The modes of application of a whole skin graft and a split-skin graft are similar in principle and in actual practice differ in only a

Dressing the graft (Fig 3, 24)

A layer of tulle gras laid over the graft before the tie over cotton wool bolus is applied tends to ease the first post operative dressing but is by no means essential What *is* essential is the careful packing of the graft area with the cotton wool and this

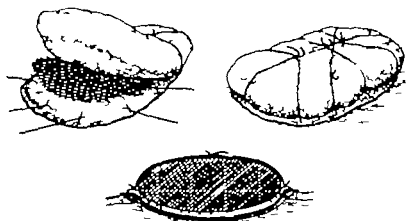


FIG 3, 24

The tie-over dressing

must be done meticulously so that the graft as a whole is subjected to uniform pressure The plug must be bulky and extend to the margin of the graft The most efficient shape is probably one with a circular cross section which will spread the pressure evenly With the wool tightly packed in position the long tie over sutures are tied tightly over the dressing anchoring dressing and graft in one mass

The material best suited to act as a plug is cotton wool prepared with flavine emulsion Alternatives are cotton wool moistened with saline or tightly wrung out with liquid paraffin but flavine wool * is much to be preferred because of its fluffing properties

Over further cotton wool padding to diffuse the pressure

Preparation of flavine wool The materials used are flavine emulsion and best quality cotton wool or Gamgee A sheet of cotton wool is soaked in the emulsion previously warmed to reduce its viscosity until it is completely impregnated The excess of emulsion is then removed from the cotton wool It is at this point that the usefulness of Gamgee becomes apparent for the covering gauze adds to the strength of the material which can be rolled up and wrung out by hand This must be done thoroughly until the cotton wool appears virtually dry and no more emulsion can be extracted The sheet of cotton wool is left to dry off on a warm surface and when autocla ed is ready for use For ease of handling it can be wrapped in cellophane or packed in a tin

The graft should be cut large enough to overlap the raw area slightly and there is no need to fit it accurately to the defect It will take only to the margin of the defect in any case and the overlap can be trimmed off readily when the graft is dressed If the margin is accurately sutured edge to edge it is apt to inroll

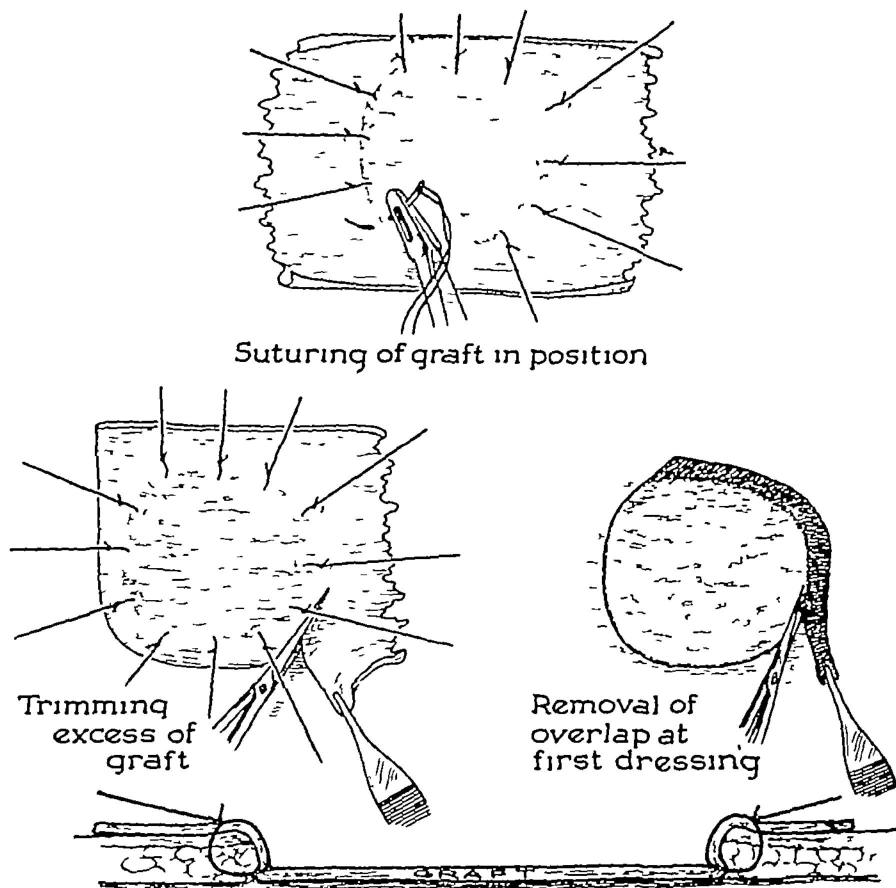


FIG 3, 23

The application and suturing of a split-skin graft

and this gives a poor scar The overlapping suture avoids this and also allows reduction of the number of sutures needed, for as long as the graft continues to overlap the defect between the sutures it will cover the raw area

At one time this technique was used only when a good cosmetic result was not essential and in the face for example the graft was carefully sutured end to end More recently, the overlapping method has been used even in the face with great simplification of technique and cosmetic results in no way inferior

Bacterial flora

Any of the common organisms may infect an area according to site and circumstances With the exception of *Str pyogenes* and *Ps pyocyanea* such organisms are of little consequence as a general rule and clinical appearance is a better guide than bacterial flora in assessing suitability for grafting

Str pyogenes The presence of this organism is an absolute contra indication to any grafting procedure its possible presence necessitates routine bacteriological examination of exudate before grafting is contemplated Why a graft should fail when it is present is not exactly known though interference with the normal fibrin attachment of the graft by the fibrinolysin which it produces may possibly be the cause

Classically granulations harbouring *Str pyogenes* are glazed gelatinous and bleed readily at the slightest touch the marginal epithelium is seldom healthy and growing With the routine use of antibiotics the classical picture may not be seen and the granulations may look quite healthy But this deceptively tranquil behaviour of *Str pyogenes* does not mitigate its destructive effect on grafts It must always be eliminated before grafting is attempted

Ps pyocyanea. Infection with this organism does reduce graft take but not to an extent comparable with *Str pyogenes* and its presence is a nuisance rather than a disaster

Its epidemiology is curious and unexplained When a large number of burned patients are being nursed together it may be quite absent for several months For no apparent reason it then appears on one burn and despite all the usual precautions rapidly spreads to infect almost every burned area in the ward No specific steps can be taken to control the spread of infection because the mode of spread is not precisely known Curiously enough after a period of some weeks the infection disappears as suddenly as it arose

The only antibiotic to which *Ps pyocyanea* is at all sensitive is Polymyxin E and its use locally has been recommended by the Medical Research Council Burns Research Unit But while *Ps pyocyanea* may reduce graft take by 5–10 per cent at most grafting of the area on the other hand does tend to end the infection Grafting regardless of *Ps pyocyanea* and accepting any small reduction in take gives excellent results

crepe bandages are applied If the site lends itself better to immobilisation by elastoplast this should be used instead The objective is as complete immobility as can be achieved and both the elastoplast and crepe are used to this end Plaster of Paris should be used if it is felt that it will add significantly to the overall immobility of the grafted area

The Granulating Area

In assessing a granulating area for grafting two factors are of importance—clinical appearance and bacterial flora

Clinical appearance

Healthy granulations are flat, red and vascular, do not bleed unduly readily, and are free from a surface film of sloughing collagen Good marginal healing is presumptive evidence that granulations will accept a graft for it can be assumed that infection virulent enough to destroy a graft would be inimical to marginal epithelial growth

Unsatisfactory granulations take several forms

1 Granulations left ungrafted for any length of time become more fibrous and less vascular so that it becomes increasingly difficult to get a graft to take Infection tends to add to the difficulties of grafting in those circumstances

2 When subjected to inadequate pressure, granulations tend to become oedematous and in this state are often miscalled exuberant Such granulations need pressure rather than excision and copper sulphate has certainly no place in the care of any surface which it is proposed to graft Its only effect is to produce a coagulum which must be cast before a graft will take

3 Haemorrhages are prone to take place into oedematous granulations producing a very typical clinical appearance

4 The typically gelatinous, haemorrhagic granulations harbouring *Str pyogenes*, which will be discussed later

5 When a slough separates naturally the granulations left often have a tenacious film of necrotic collagen which is slow to separate and difficult to rub off

invasive infection the flora is to be regarded as innocuous only when the slough has gone is it possible to reduce the flora

The chemical agents for debridement—phosphoric and pyruvic acid which act by altering the local pH are unsatisfactory They are painful impossible to use in a sterile fashion and when the main slough has separated there is left a tenacious film of sloughing collagen which must be removed before grafting More recently they have been replaced by the enzymatic agents streptodornase streptokinase and trypsin but these have not achieved great popularity and appear to have little to offer over the established methods Eusol has still much to recommend it both for cleaning up dirty granulations and removing sloughs which are moist diffluent, and difficult to excise cleanly The Humby knife has been used with the roller widely open to excise both slough and heavily infected granulations and is most effective in the role as is also the electric dermatome

When granulations are clean and free of slough they should be grafted without delay During such waiting as is unavoidable an innocuous dressing which will not damage the granulations when removed should be used and tulle gras is usual Unless *Str pyogenes* is present an antibiotic is not essential A meticulous dressings technique adequate cover both in area and thickness of dressing and infrequent dressings provide a better insurance against superadded infection than a blind reliance on antibiotics The other factor which will keep granulations as healthy as possible for the longest time is pressure and crepe bandages are usually necessary to provide this

Applying the graft

Spreading the graft on a sheet of tulle gras (Fig 3 25) eases handling tulle gras and graft can then be directly applied to the granulating area The graft is not usually sutured in place though in a difficult situation a few tacking sutures may help to prevent it sliding off the granulations while the dressing is being applied There is no question of using the sutures for a tie over dressing for they would cut out very rapidly

The fixation of the graft is naturally much less secure than that of a tie over dressing and it is liable to slip during the first few turns of the bandage if these are not carefully applied The outer dressing consists of the usual gauze cotton wool and crepe

In short a positive culture of *Ps pyocyanea* is not a contra-indication to grafting if the granulations look otherwise healthy

Other pathogens. The other pathogens which commonly infect wounds are *Staph aureus*, which in this situation is seldom more than a commensal, *Bact coli*, and *B proteus* These latter two organisms are especially common in the badly handled, heavily contaminated, granulating wound They are associated as a rule with a very typical, profuse, foul-smelling discharge and often occur as a mixed infection with *Ps pyocyanea* In the extensive deep burn they are often impossible to avoid but all too often they are allowed to contaminate quite small wounds from which ordinary care would readily exclude them

Preparing granulations for grafting

It is axiomatic that the granulating area is being treated, not its flora, and so the role of local antibiotics is a controversial one Antibiotics should not be used blindly on the basis of sensitivity reports *Str pyogenes* apart, the flora is immaterial provided the granulations look healthy and the fastest way to eliminate the flora is to graft the area

In deciding the appropriate steps to eliminate *Str pyogenes* from a granulating area the organism cannot be considered in isolation Penicillin is the obvious antibiotic to use when it is the sole pathogen, for no resistant strains have been demonstrated When it is associated with a penicillin resistant staphylococcus however the penicillinase produced by the staphylococcus makes penicillin much less effective and the antibiotic to which both are found to be sensitive is preferable Alternatively one of the newer antiseptic agents such as chlorhexidine ("Hibitane") may be used

The main cause of continuing infection is the presence of slough, measures to get rid of it always reduce the infection Surgical excision is the most rapid and effective method and in excising slough it pays to be as radical as is feasible Excision to fascia is preferable to excision to fat The alternative methods are natural separation unaided or helped by Eusol or the enzymatic agents for debridement

Where a slough is separating naturally, pus is inevitable and is by no means undesirable for its autolytic enzymes play a valuable part in separating living from dead tissue If there is no sign of

invasive infection the flora is to be regarded as innocuous only when the slough has gone is it possible to reduce the flora

The chemical agents for debridement—phosphoric and pyruvic acid which act by altering the local pH are unsatisfactory They are painful impossible to use in a sterile fashion and when the main slough has separated there is left a tenacious film of sloughing collagen which must be removed before grafting More recently they have been replaced by the enzymatic agents streptodornase streptokinase and trypsin but these have not achieved great popularity and appear to have little to offer over the established methods Eusol has still much to recommend it both for cleaning up dirty granulations and removing sloughs which are moist diffluent, and difficult to excise cleanly The Humby knife has been used with the roller widely open to excise both slough and heavily infected granulations and is most effective in the role as is also the electric dermatome

When granulations are clean and free of slough they should be grafted without delay During such waiting as is unavoidable an innocuous dressing which will not damage the granulations when removed should be used and tulle gras is usual Unless *Str pyogenes* is present an antibiotic is not essential A meticulous dressings technique adequate cover both in area and thickness of dressing and infrequent dressings provide a better insurance against superadded infection than a blind reliance on antibiotics The other factor which will keep granulations as healthy as possible for the longest time is pressure and crepe bandages are usually necessary to provide this

Applying the graft

Spreading the graft on a sheet of tulle gras (Fig 3, 25) eases handling tulle gras and graft can then be directly applied to the granulating area The graft is not usually sutured in place though in a difficult situation a few tacking sutures may help to prevent it sliding off the granulations while the dressing is being applied There is no question of using the sutures for a tie over dressing for they would cut out very rapidly

The fixation of the graft is naturally much less secure than that of a tie over dressing and it is liable to slip during the first few turns of the bandage if these are not carefully applied The outer dressing consists of the usual gauze cotton wool and crepe

bandage or elastoplast Bulk of dressing may be enough to produce immobility but plaster of Paris should always be used if need be to reinforce the dressings

The pros and cons of stamp grafting

It became usual during the 1939-45 War when large granulating areas had to be grafted to cut the graft into squares of postage

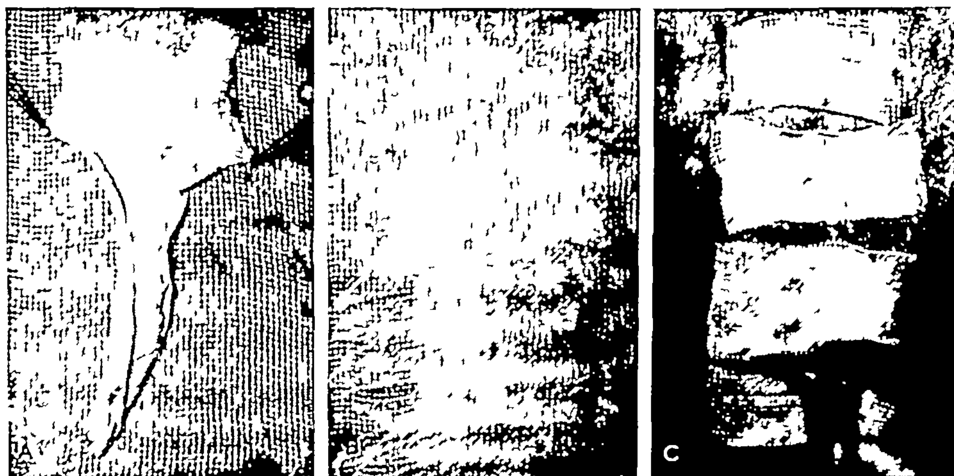


FIG 3, 25

The handling of a split-skin graft on tulle gras

A Laying the graft on the tulle gras which has been spread on a wooden board
B The graft spread on the tulle gras
C Cutting the graft into strips

stamp size and to apply these stamps rather than large strips or sheets of skin Several reasons were given for this

1 By spacing the stamps a small amount of skin could be expanded to cover a large area

2 The spaces between the stamps allowed the escape of pus, exudate, etc , without lifting off the graft

3 Where fixation was difficult, as in the perineum or axilla, stamps were less likely to be dislodged than a sheet of skin which might become ruffled

It must be realised that methods of preparing virtually sterile granulations have improved greatly since then so that some of the arguments in favour of stamps have lost their cogency Stamps too have their own disadvantages

1 The mosaic of stamp alternating with spread epidermis

tends to give a poor cosmetic result The actual appearance shows wide and quite unpredictable variation At one extreme the spread epidermis is smooth and not unlike the stamps at the other it becomes hypertrophic or even keloid Initially redder it usually pales to a colour more nearly matching the stamp over a period of months

2 The spread epidermis is less stable and in the lower limb if not supported with crepe bandages for a considerable period small haemorrhagic blisters tend to form Gradually it becomes more stable stability and cosmetic improvement usually progressing together

The idea that stamp grafts would allow pus to escape was of doubtful truth even when originally stated and with current methods of preparing granulations it certainly has no validity Where ample skin is available and the granulations are healthy large strips with no intervening gap or even whole sheets (Fig 3, 26) are preferable With granulations less satisfactory though still graftable stamps may be safer since at least some stamps may survive where a whole sheet might be lost Multiple puncture of sheet grafts has been advocated to allow escape of potential exudate but it is found in the event that the exudate only continues in areas uncovered by graft so that puncture is quite unnecessary

In short stamps are mainly justifiable where skin is in short supply and where fixation is particularly difficult

STORAGE OF SKIN

By storage at a low temperature skin cut in excess of current requirements can be preserved viable for later use as needed Within the temperature range 0–37 C the survival time of a stored graft is a function of its temperature and the lower the temperature the longer the survival time

The experimental work which shows this has been done mainly with animal skin but enough is known of the behaviour of human skin similarly stored to make the results clinically applicable For long survival Ringer s or Tyrode s solution should probably be used to keep the graft moist but normal saline works adequately The graft is wrapped in gauze wet with the solution and placed in a sterile sealed container Unless specially long survival

bandage or elastoplast Bulk of dressing may be enough to produce immobility but plaster of Paris should always be used if need be to reinforce the dressings

The pros and cons of stamp grafting

It became usual during the 1939–45 War when large granulating areas had to be grafted to cut the graft into squares of postage

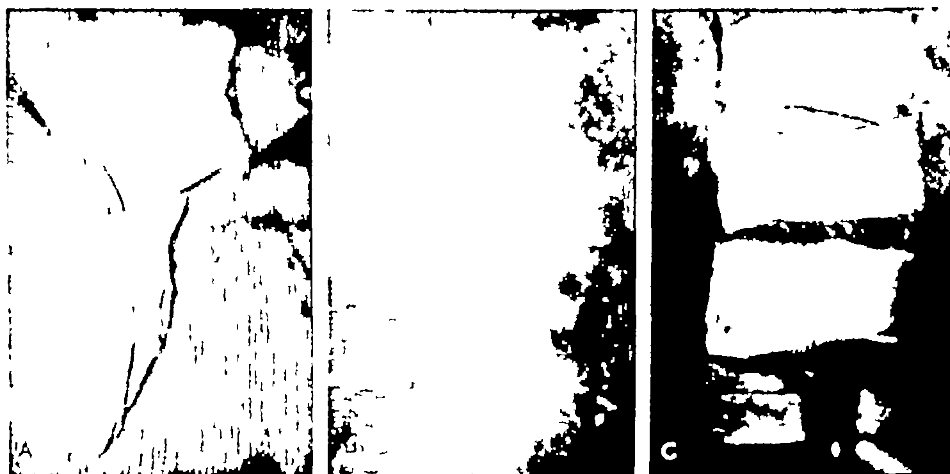


Fig 3, 25

The handling of a split-skin graft on tulle gras

A Laying the graft on the tulle gras which has been spread on a wooden board
B The graft spread on the tulle gras
C Cutting the graft into strips

stamp size and to apply these stamps rather than large strips or sheets of skin Several reasons were given for this

1 By spacing the stamps a small amount of skin could be expanded to cover a large area

2 The spaces between the stamps allowed the escape of pus, exudate, etc , without lifting off the graft

3 Where fixation was difficult, as in the perineum or axilla, stamps were less likely to be dislodged than a sheet of skin which might become ruffled

It must be realised that methods of preparing virtually sterile granulations have improved greatly since then so that some of the arguments in favour of stamps have lost their cogency Stamps too have their own disadvantages

1 The mosaic of stamp alternating with spread epidermis

e g up to 21 days is needed the storage temperature is not of paramount importance but it seems probable that 4 C is likely to give the best results

LOCAL ANAESTHESIA FOR GRAFT CUTTING

Formerly the use of local anaesthesia for graft cutting was restricted by the uneven surface which infiltration produced coupled with the large volume of anaesthetic agent needed The use of hyaluronidase has removed these drawbacks and it is possible now to cut quite large grafts readily if the enzyme is added to the anaesthetic solution The solution diffuses so rapidly that it is difficult to define exactly the area infiltrated and it is wise to outline the area to be anaesthetised with Bonney s Blue so that it can be systematically infiltrated The exact amount of hyaluronidase which has to be used is not critical 1 500 international units added to 100 ml of anaesthetic solution will be found to work satisfactorily

BIBLIOGRAPHY

Vascularisation of grafts

CALNAN J & INNES F L F (1957) Exposed delayed primary skin grafts *Brit J plast Surg* 10 11

DAVIS J S & TRAUT H F (1925) Origin and development of the blood supply of whole-thickness skin grafts *Ann Surg* 82, 871

MCLAUGHLIN C R (1954) Composite ear grafts and their blood supply *Brit J plast Surg* 7 274

SMITH F (1926) A rational management of skin grafts *Surg Gynec Obstet* 42, 556

Healing of donor sites

CONVERSE J M & ROBB SMITH A H T (1944) The healing of surface cutaneous wounds *Ann Surg* 120 873

Infection of granulations

CLARKSON P & LAWRIE R S (1946) The management and surgical resurfacing of serious burns *Brit J Surg* 33, 311

JACKSON D M LOWBURY E J L & TOPLEY E (1951) *Pseudomonas pyocyanea* in burns *Lancet* ii, 137

JACKSON D M LOWBURY E J L & TOPLEY E (1951) Chemotherapy of *Str pyogenes* infection of burns *Lancet* ii, 705

LIEDBERG N C KUHN L R BARNES B A REISS E & AMSPACHER W H (1954) Infection in burns *Surg Gynec Obstet* 98 693



FIG 3, 26

The use of large sheet split-skin grafts in covering a granulating area of thigh

CHAPTER FOUR

Flaps, Pedicles and Tubes

THESE types of tissue transfer are basically similar and the general term *flap* will be used to cover all three

The essential difference between a flap and a free skin graft lies in the factor of blood supply for in contra-distinction to the free skin graft a flap retains a vascular attachment to the body at all

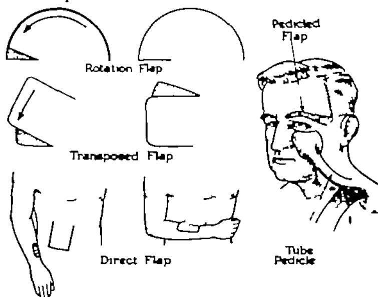


FIG 4, 1

The basic types of flap transfer

times during transfer This implies in every flap a functioning vascular system both arterial and venous capable of maintaining an adequate circulation during the stages of transfer from donor to recipient site The presence of such a system enables a flap to be transferred to an area whose blood supply would be inadequate to nourish a free skin graft and this very factor is a frequent reason for using a flap in preference to a free skin graft

There are many different types of flaps (Fig 4, 1) Raised

Storage of skin

PEPPER, F. J. (1954) Studies on the viability of mammalian skin autografts after storage at different temperatures. *Brit. J. plast. Surg.* 6, 250.

BUCHAN, A. C. (1958) Experimental studies on the storage of skin: the viability of human skin stored above freezing point. *Brit. J. plast. Surg.* 11, 206.

Local anaesthesia for graft cutting

CAMERON, J. A. (1951) Use of hyaluronidase to facilitate cutting of free skin grafts under local anaesthesia. *Glasg. med. J.* 32, 150.

The transfer of tissue from a distance follows one of three patterns

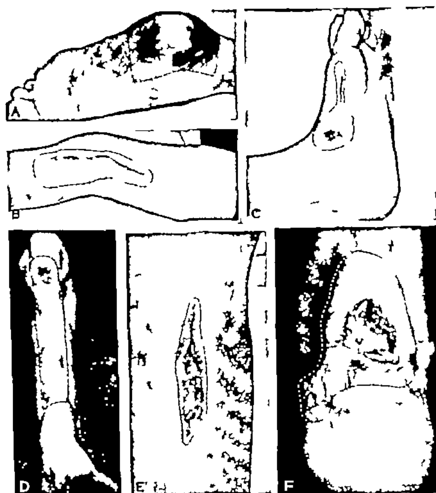


FIG 4, 2

Typical areas suitable for flap cover and the extent of excision required solely to eliminate scarring It should be appreciated that further skin may have to be excised to permit the flap to have a shape suitable from a vascular viewpoint Thus Fig 4, 18B shows the flap used to repair the defect F Stages in the repair of A are shown in Figs 4, 3 4, 6D and 4, 18D and of D in Figs 4, 7C and 4, 11A.

1 The defect is brought to the donor site from which the flap is raised and directly applied to the defect A direct flap of this type has its main use in covering defects of the arm—distally more often than proximally—with the trunk as donor site

from its donor surface like a lid or trap-door a flap may be moved to its destination in several ways, commonly by **rotation, transposition** or **direct application,** and the appropriate term is used to describe the flap The greater part or all of such a flap is applied to the recipient site, there is little or no pedicle When a flap does have a pedicle the vital element is usually its terminal segment, the remainder forms its pedicle, acts as its carrier and provides its channel of blood supply during transfer To reduce sepsis by eliminating raw surfaces the flap is often made into a tube and is then called a **tube pedicle.**

THE PLANNING OF FLAPS

Defining the defect

Before repair by a flap is contemplated the extent of the defect must be defined in terms of each component—skin, bone and lining In this the quality of the skin surrounding the obvious defect must be taken into account Skin showing radiotherapy damage or the fibrotic and atrophic changes of old scarring is not good surgical material and is often better regarded as part of the defect and excised in order to reach the good skin beyond it (Fig 4, 2) In addition to its poor suture-holding qualities the avascularity of such skin makes it unsatisfactory for nourishing a pedicle inset when the remainder of the pedicle is detached for transfer A good criterion, skin texture and appearance apart, is the state of skin mobility, skin freely mobile deeply is usually reasonably satisfactory to work with

Planning the procedure

A flap is planned in two distinct ways which, while they cannot be quite divorced in practice, are best considered separately They consist of **deciding the type of flap** and **planning the actual transfer.**

Type of flap. The transfer of a flap may involve moving tissue *adjoining the defect* or tissue *at a distance* from it

Before local tissue can be transferred it must be demonstrably available and ways of assessing its availability will be described under the heading of Rotation and Transposed Flaps

can be a contra indication in the older age group to the use of a direct flap or tube pedicle



Fig 4 3

Planning in reverse The area (Fig 4 3A) requiring replacement is covered with the jaconet flap (A) the legs are placed in the transfer position and (B and C) the flap is put into the position it will take during the actual transfer (see Fig 4 18D) The flap is then laid out on the donor area (D) and outlined with Bonney's Blue (E) to give the shape and position of the actual flap (F)

Planning the transfer With the type of flap decided its site size and shape and the stages of the transfer are planned by the method of **planning in reverse** (Fig 4 3) The defect is outlined with a suitable material such as jaconet With this

2 The donor site and the defect are both moved into close proximity to each other so that a flap can be transferred directly from one to the other This is the situation when a direct flap is transferred from leg to leg – a cross-leg flap, from forearm to opposite hand a cross-arm flap, or from finger to finger a cross-finger flap

3 The defect remains virtually static and the bulk of the movement involved in the transfer is done by the flap. This situation is typified by the tube pedicle transfer

The appropriate type of flap in any set instance tends to be governed by the **size** and **site** of the defect, and the **time factor** in the transfer

Size of the defect A local flap has to be much greater in area than the defect it is planned to cover and the limbs are seldom able to provide enough tissue to cover the size of limb defect which commonly requires flap cover In the trunk and face the necessary area of tissue is more likely to be present and the local flap more often a practical possibility

The area of tissue which is readily transferred as a direct flap is considerably smaller than that which can be transferred as a tube pedicle and large defects generally require a tube pedicle

Site of the defect When the choice lies between a direct flap and a tube pedicle a direct flap can only be used if the defect and donor area are capable of ready approximation This limits the direct flap to defects of arm and hand, and lower leg and foot

The interplay of size and site as it affects the local flap has been described above

The time factor The actual transfer of a direct flap is completed in 4–5 weeks, the tube pedicle transfer often takes three times as long The direct flap can be used as an emergency procedure, subject to certain dimensional limiting factors, the tube pedicle can only be used in an elective fashion for it has to be raised and tubed before the transfer is begun

The local flap is virtually completed in a single stage and may be desirable on this score It does not involve the patient in maintaining a particular position for a period of time as do both the direct flap and tube pedicle The need to maintain a position for a prolonged period with the bed rest which this may occasion

and thickness which would not be necessary otherwise and subsequent trimming thinning and Z-plasties have often to be carried out after the flap has completed its transfer to give the optimal result (Fig 4, 4)

VASCULAR ASPECTS OF FLAPS

Blood supply governs all flap practice and a clear understanding of this aspect will explain much which would otherwise be inexplicable in the construction and transfer of individual flaps

Vascular Adjustments

Flaps consist in most instances of skin and superficial fascia If a block of such tissue *in situ* is considered from the viewpoint of blood supply it may be assumed that its content of blood vessels in respect of number and calibre is the most efficient physiologically Its free ingress of arterial blood and egress of venous blood are quantitatively governed largely by its metabolic requirements In ordinary circumstances this flow is a mere fraction of its potential vascular capacity the reserve factor is considerable A common circumstance which calls on at least part of this vascular reserve is an acute inflammatory reaction Such a reaction is well within the capacity of the normal circulation to sustain in all but the most virulent infections unless the reserve is reduced as in arteriosclerosis of the lower limb when a mild infection can trigger off a spreading gangrene

A flap differs from the surrounding skin in that its quota of arteries and veins is strictly limited. This can be seen if one *considers the theoretical situation of a square flap with vascular* pattern distributed equally on each side and its deep surface Raising such a flap to leave it attached by one side alone reduces its vascular capacity to $\frac{1}{5}$ and though such a theoretical distribution of blood vessels does not hold in practice the principle of reduction of vascular capacity does

If however it were possible to cut off the other four vascular attachments gradually it would be found that the pattern of the flap had adjusted itself so that its capacity and reserve remained almost normal It has also been shown experimentally that following the raising of a tube pedicle the mean blood pressure

representing the flap the procedure is carried from the end result backwards through the various stages with the limbs in their correct position until the "flap" ends up on the skin area from which it is to be taken, where it is used to outline the definitive flap In this way the patient is not given an impossible position



FIG 4, 4

The result immediately following the completion of the transfer of tube pedicles to correct post-burn neck contractures and after Z-plasties coupled with thinning A previous stage in the transfer of (A) is shown in Fig 4, 11B and the tube pedicle used for (B) is shown in Fig 4, 7D

to maintain at a critical stage of the transfer and the surgeon avoids a flap which is too small, one which will kink during transfer or fail to reach its destination because it is too short Time spent on the planning stage is never wasted in the long run

A flap should always be planned with a margin of reserve Skimping, making it just neat, will certainly create difficulties for the surgeon in due course It is easy to trim an excessively large flap, but difficult to add to one, once begun

The exigencies of blood supply may dictate dimensions, shap

and thickness which would not be necessary otherwise and subsequent trimming thinning and Z-plasties have often to be carried out after the flap has completed its transfer to give the optimal result (Fig 4, 4)

VASCULAR ASPECTS OF FLAPS

Blood supply governs all flap practice and a clear understanding of this aspect will explain much which would otherwise be inexplicable in the construction and transfer of individual flaps

Vascular Adjustments

Flaps consist in most instances of skin and superficial fascia If a block of such tissue *in situ* is considered from the viewpoint of blood supply it may be assumed that its content of blood vessels in respect of number and calibre is the most efficient physiologically Its free ingress of arterial blood and egress of venous blood are quantitatively governed largely by its metabolic requirements In ordinary circumstances this flow is a mere fraction of its potential vascular capacity the reserve factor is considerable A common circumstance which calls on at least part of this vascular reserve is an acute inflammatory reaction Such a reaction is well within the capacity of the normal circulation to sustain in all but the most virulent infections unless the reserve is reduced as in arteriosclerosis of the lower limb when a mild infection can trigger off a spreading gangrene

A flap differs from the surrounding skin in that its quota of arteries and veins is strictly limited This can be seen if one considers the theoretical situation of a square flap with vascular pattern distributed equally on each side and its deep surface Raising such a flap to leave it attached by one side alone reduces its vascular capacity to $\frac{1}{5}$ and though such a theoretical distribution of blood vessels does not hold in practice the principle of reduction of vascular capacity does

If however it were possible to cut off the other four vascular attachments gradually it would be found that the pattern of the flap had adjusted itself so that its capacity and reserve remained almost normal It has also been shown experimentally that following the raising of a tube pedicle the mean blood pressure

in the tube drops to 25 per cent of normal rising to 90 per cent by the end of 4–6 weeks How do such re-adjustments occur? It is well recognised that there is tremendous lability of vascular pattern with a flexible response to local requirements Little is known of the physics of these changes but a more efficient vascular pattern is presumably produced The pattern changes have not been worked out in detail but the end result seems to be an axial reorientation of the larger blood vessels with an increase in number and calibre The means adopted in practice to induce these highly desirable pattern changes will be considered later

It has been stated that the vessels of a flap are sympathectomised and dilated but this is not so They are in actual fact completely denervated and the physiological consequences of complete denervation are quite different from those which follow sympathectomy alone, the vessels appear to develop an autonomous state of tone Certainly the normal skin colour indicates that they are not dilated and they are able to produce in appropriate circumstances apparently normal reactions of reactive hyperaemia and acute inflammation

Vascular Insufficiency

In a flap suffering from vascular insufficiency the difficulty in most cases is not the getting of blood into the flap, but getting the blood which is in out It is "circulation" which is the problem To lose a flap because of pure arterial insufficiency is a rarity, to lose part or all of it because of venous insufficiency is all too common Flaps die in congestion and not anaemia Several factors play a part singly or together in tending to embarrass the circulation

Mechanical tension When transferring a flap the tissues must not be sutured under greater than normal tension, rather should they be under less than normal tension Undue tension tends to embarrass both the venous and arterial flow, particularly the venous

Kinking With arterial pressure higher than venous pressure kinking of a flap impairs the venous drainage initially and makes the flap congested It tends to be most serious when the flap lacks flexibility and is always aggravated by any increase in tissue turgor

Oedema When oedema develops it contributes to and enhances the ill effects of tension and kinking Skin initially lax and wrinkled becomes shiny and swollen and particularly in the confining circumstances of a tube pedicle there is obstruction of venous flow and still further increase of turgor

Transient oedema is common even in the flap which is progressing favourably increasing over the first 24–36 hours It remains for a further 2–3 days and the appearance of fine wrinkling of the shiny oedematous skin is the first sign of its passing as the circulation becomes more efficient

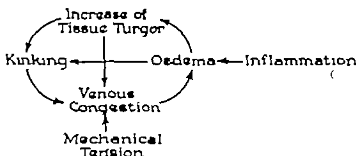


FIG 4, 5

The vicious circle of circulatory embarrassment in a flap

Inflammation The vascular reserve of a flap is never normal and while it may be adequate to cope with ordinary metabolic needs the added burden of an inflammatory reaction must always be an embarrassment The soil rather than the seed is the critical factor and infection which would be of minor significance elsewhere can produce necrosis of quite disastrous extent in a flap When an inflammatory reaction does develop tension becomes an added factor in causing the necrosis to spread

For clarity these factors have been discussed separately but they seldom act singly in practice One factor may initiate the vicious circle of increased tissue turgor leading to venous congestion leading in turn to increased tissue turgor but rapidly the others come into action to aggravate the cycle schematically indicated in Fig 4, 5

Flap Necrosis

Developing necrosis in a flap presents clinically with the skin acutely congested cyanosed blanching momentarily on pressure but with vessels rapidly filling again the vascular bed is dilated

in the tube drops to 25 per cent of normal rising to 90 per cent by the end of 4–6 weeks How do such re-adjustments occur? It is well recognised that there is tremendous lability of vascular pattern with a flexible response to local requirements Little is known of the physics of these changes but a more efficient vascular pattern is presumably produced The pattern changes have not been worked out in detail but the end result seems to be an axial reorientation of the larger blood vessels with an increase in number and calibre The means adopted in practice to induce these highly desirable pattern changes will be considered later

It has been stated that the vessels of a flap are sympathectomised and dilated but this is not so They are in actual fact completely denervated and the physiological consequences of complete denervation are quite different from those which follow sympathectomy alone, the vessels appear to develop an autonomous state of tone Certainly the normal skin colour indicates that they are not dilated and they are able to produce in appropriate circumstances apparently normal reactions of reactive hyperaemia and acute inflammation

Vascular Insufficiency

In a flap suffering from vascular insufficiency the difficulty in most cases is not the getting of blood into the flap, but getting the blood which is in out It is "circulation" which is the problem To lose a flap because of pure arterial insufficiency is a rarity, to lose part or all of it because of venous insufficiency is all too common Flaps die in congestion and not anaemia Several factors play a part singly or together in tending to embarrass the circulation

Mechanical tension When transferring a flap the tissues must not be sutured under greater than normal tension, rather should they be under less than normal tension Undue tension tends to embarrass both the venous and arterial flow, particularly the venous

Kinking With arterial pressure higher than venous pressure kinking of a flap impairs the venous drainage initially and makes the flap congested It tends to be most serious when the flap lacks flexibility and is always aggravated by any increase in tissue turgor

termed a **delay** and is achieved either by surgically dividing the unwanted vessels or by clamping the pedicle where possible the so-called physiological delay



FIG 4, 6

Examples of surgical delays

A. Pancake flap delayed on to one end of an acromio-pectoral tube pedicle used to repair radionecrotic ulcer of chin shown in Fig 5 6B
B Delay of cross leg flap Subsequent stages shown in E and Fig 4, 18A
C Lengthening an abdominal tube pedicle by delay
D Delay of the segment of the cross thigh flap (see Fig 4, 18D) planned in Fig 4, 3 which was intended to cover the heel of the foot
E Delay of cross-leg flap (see B and Fig 4, 18A) prior to detaching and inserting the flap

The surgical delay A surgical delay permits the use of a greater length breadth ratio than would be possible without it An *incision is made along the line across which the surgeon* wishes to cut off the blood supply the blood vessels crossing the line are divided ligated if need be and the wound is resutured and allowed to heal (Fig 4, 6) This only divides marginal vessels and to cut off the blood supply entering the deep surface the flap must be elevated and the entering vessels divided and ligated before

and largely stagnant As the condition progresses, blanching on pressure becomes less and less definite until there is clearly no active circulation The cyanosis remains and takes on a violaceous tint Histologically there is gross extravasation of blood. Blistering of the skin with serum, or blood-filled blebs, usually develops When the blister skin is removed the underlying skin is moist, cyanosed and without demonstrable circulation Although the development of such blisters indicates that some circulation is still present it also implies that the onset of necrosis is virtually inevitable and imminent At this point the margin of the affected area is seldom well demarcated and the process tends to spread for the reasons already indicated The final area of necrosis is often more extensive than appearances at the onset might have suggested This is so because the process will not halt until a skin area has been reached whose vascular capacity is able to cope not merely with ordinary metabolic needs, but also with the added vascular burden of the adjacent necrosis and any superadded infection When the process eventually does stop spreading a good line of demarcation is present with, just proximal to it, a zone of inflammation well sustained from a vascular viewpoint

This then is the picture of the untreated, florid, progressive process of flap necrosis

Prevention of Flap Necrosis

Steps can be taken at all stages to prevent flap necrosis—in the initial design of the flap, by enhancing its vascular efficiency and by care during and after transfer

Initial design of the flap

This involves such factors as the length-breadth ratio, the intrinsic vascular pattern of the flap, its anatomical situation, etc , and the problems will be discussed as they relate to the planning of each kind of flap The design should always allow for the normal increase in tension which the phase of oedema creates

Enhancement of vascular efficiency

By cutting off the unwanted blood vessels the flap is "trained" to rely *only on* those vessels which are actually to be functioning during the subsequent stage of the transfer This measure is

Care during and after transfer

It is after transfer particularly that skilled and experienced nursing can be invaluable not merely in preventing trouble through careful positioning of the patient but in recognising the danger signals of circulatory embarrassment early while they are still readily reversible and before the inexorable progress which leads to necrosis has begun in real earnest It is at this time too that a good nurse can provide the encouragement so necessary to a patient during the early hours and days of what for him is so often an agonisingly uncomfortable position

There are several ways however in which the surgeon can anticipate and prevent the potential troubles which can arise post operatively

Haemostasis A developing haematoma is prone to initiate the increase of tension which starts the cycle of events already described Haemostasis is easier to achieve if planes of cleavage are used for the vessels crossing are large and few and are readily ligated A previous delay tends to obscure these and a diffuse ooze is more common

A pressure dressing sometimes helps but as already stressed there is the difficulty of getting just the correct pressure

Use of gravity Egress of blood from the flap is the usual problem and where possible gravity should be used to help venous drainage The foot of the bed can usefully be raised on occasion and the Balkan frame may be employed for suspending the appropriate part of a limb

Control of sepsis Infection as a factor operates at all stages and with the one exception of head and neck flaps all skin surfaces are best healed before the next stage of the transfer is contemplated Skin preparation must be scrupulous and though asepsis is often difficult to achieve at every stage of the various operations involved in the transfer it must be realised that each break in technique does endanger the procedure Planning at each stage to avoid raw surfaces is important and this topic is discussed on page 118

Methods designed to encourage active circulation These consist of the intermittent inflation of a sphygmomanometer cuff placed strategically either to drive blood into or out of a tube pedicle It is the flow out of a flap which needs encouragement as a rule

returning the flap to its original position In a difficult situation the flap can be delayed in stages Such vascular link-up as may occur during healing of the incision is not enough to prevent the redeployment of blood vessels which results

How soon the delay can be assumed to have achieved its purpose has never been properly worked out experimentally and the time is dictated by the healing of the incision The next stage is proceeded with when the delay has healed, usually in 7–10 days

It must be recognised that the delay is a double-edged weapon capable of operating against as well as for the surgeon This is true especially of the delay involving elevation for, no matter how delicate the technique, reaction of the separated surfaces is always produced and is around its peak at the tenth day Excision of this indurated surface when the flap is actually transferred does not altogether eliminate the zone of reaction and its presence undoubtedly reduces the flexibility of the flap, making kinking both more likely and more serious It is desirable to reduce reaction to an absolute minimum by using planes of cleavage In the limb this is at the junction of superficial and deep fascia, in the abdomen at the junction of superficial fascia and aponeurosis In the chest and back no real plane exists, but the best substitute is close to muscle

Haematoma too adds to the reaction and should be avoided by scrupulous haemostasis A carefully applied pressure dressing post-operatively will prevent the accumulation of fluid under a flap though a balance between too little pressure which allows fluid to gather and too much which causes ischaemic necrosis is not always easy to achieve

Surgeons vary greatly in the extent to which they use the delay Though a delay may seem to waste time it does on the whole make flap transfer safer and on this score may reasonably be considered a time-saver since the paramount cause of wasted time is loss of part of a flap during its transfer

The physiological delay This measure is useful mainly in the tube pedicle and trains it to rely for its vascular support on one end alone The pedicle is compressed, either by an inflated sphygmomanometer cuff, or a suitably padded intestinal clamp, initially for short periods, gradually lengthening

Care during and after transfer

It is after transfer particularly that skilled and experienced nursing can be invaluable not merely in preventing trouble through careful positioning of the patient but in recognising the danger signals of circulatory embarrassment early while they are still readily reversible and before the inexorable progress which leads to necrosis has begun in real earnest It is at this time too that a good nurse can provide the encouragement so necessary to a patient during the early hours and days of what for him is so often an agonisingly uncomfortable position

There are several ways however in which the surgeon can anticipate and prevent the potential troubles which can arise post operatively

Haemostasis A developing haematoma is prone to initiate the increase of tension which starts the cycle of events already described Haemostasis is easier to achieve if planes of cleavage are used for the vessels crossing are large and few and are readily ligated A previous delay tends to obscure these and a diffuse ooze is more common

A pressure dressing sometimes helps but as already stressed there is the difficulty of getting just the correct pressure

Use of gravity Egress of blood from the flap is the usual problem and where possible gravity should be used to help venous drainage The foot of the bed can usefully be raised on occasion and the Balkan frame may be employed for suspending the appropriate part of a limb

Control of sepsis Infection as a factor operates at all stages and, with the one exception of head and neck flaps all skin surfaces are best healed before the next stage of the transfer is contemplated Skin preparation must be scrupulous and though asepsis is often difficult to achieve at every stage of the various operations involved in the transfer it must be realised that each break in technique does endanger the procedure Planning at each stage to avoid raw surfaces is important and this topic is discussed on page 118

Methods designed to encourage active circulation These consist of the intermittent inflation of a sphygmomanometer cuff placed strategically either to drive blood into or out of a tube pedicle It is the flow out of a flap which needs encouragement as a rule

and this is probably the more valuable use of the method The cuff is wrapped round the pedicle inset where necrosis is most likely to occur and intermittently inflated Continuous pressure has also been advocated with the object of forcing the blood out into the veins by increasing the general pressure on the flap, in effect to provide an alternative peripheral resistance to the atonic, dilated local capillary bed of the flap suffering from vascular insufficiency The optimum pressure is thus just below capillary pressure

It is impossible to say after the event what might have happened had an alternative method been used and critical assessment of the method is difficult Similar criticisms apply to intermittent pressure Further, it needs a real effort of will to cover up a flap whose circulation is precarious so that its progress cannot be seen

On the other hand, the interference of gentle massage to try to keep the circulation going, inspection, etc , do more harm than good They produce local hyperaemia in normal tissues and this is exactly what one wishes to avoid in a flap It may well be that much of any success achieved by pressure techniques results from the rest which the flap is allowed Neither intermittent nor continuous pressure methods have achieved much popularity

Treatment of Flap Necrosis

There is a limit to what can be done to save a flap in danger of necrosing, but the very presence of necrotic tissue inviting superadded infection tends to spread the process and the surgeon may make the bold decision to detach the flap, excise the dying segment, and re-inset it in the hope that removal of the necrotic focus will give the flap a fresh start His problem is then to decide where the line of excision should be, and a good indication of the viability of a flap margin is the state of dermal bleeding, its colour and quantity

Such a drastic course is only possible if the flap has been planned with a margin of safety and failing this, a conservative policy must be pursued, awaiting slough demarcation and separation When the resulting surface is favourable a split-skin graft may be applied but the disastrous effect of infection and fibrosis on the vascular attachment must be recognised and each subsequent step

requires redoubled care and the use of delays etc It is unfortunately true that a disaster of this sort during a flap transfer makes subsequent similar disasters much more probable



Fig 4, 7

Examples of tube pedicles

A Acromio pectoral tube
B Abdominal tube
C Double abdominal tube with connecting bridge ready for tubing to complete the long tube pedicle
D Tube pedicle of scapular region The unusual site was chosen to correct a post burn contracture of neck because the usual sites had sustained full thickness skin loss burning
E Abdominal tube of unusual direction to be inset into the hand The direction was chosen to suit positioning of the hand during insetting
F Clavicular tube pedicle

THE TUBE PEDICLE

This is a bipedicled flap which when raised is turned in on itself to form a tube (Fig 4, 7) It is usually raised on the torso for transfer either to the head and neck or one of the limbs

Once raised and tubed the pedicle is left to mature for 6 weeks during which time the axial vascular re-orientation already

described is developed To give a good start to axial redeployment the tube is placed along a line of venous orientation where possible The vascular link across the mid-line of the trunk is poor and it is seldom wise to construct a flap which crosses this line The *abdominal tube pedicle* usually uses the thoraco-epigastric venous axis and the limiting length-breadth ratio is generally assessed at 2½ 1 If more length is required two tubes of standard length with a connecting bridge may be constructed In due course the bridge is delayed along its margins, raised and finally tubed to complete the "double" tube On the chest the *acromiopectoral tube pedicle* is used particularly in the male and lying as it does on a most efficient venous pathway a 3 1 ratio of length to breadth is quite safe

A tube pedicle is moved to its destination either by **attachment to a carrier,** usually the wrist, which by virtue of its mobility can carry the tube over a considerable distance in a single movement, or by **waltzing the tube** This latter method gradually "transfers" the tube by moving each end alternately and is only employed when a carrier is unnecessary or impracticable

The abdominal tube pedicle is most often carried on the wrist, the acromiopectoral tube pedicle is reserved more for repairs of head and neck in which case it is waltzed on its upper attachment to its destination This attachment should be carried well out to the shoulder tip so that shoulder as well as head movement can be utilised to reduce tube tension A tube pedicle may also be used as a carrier for a "pancake" flap (Fig 4, 6A) delayed on to one end, such a flap must be most carefully delayed in stages

The alternative sites for tubes (e g Fig 4, 7D) are used much less commonly, mainly when the usual sites are not available because of scarring, etc

Raising the tube (Fig 4, 8)

Before raising the tube it is always worth while to mark it out with Bonney's Blue and tattoo appropriate points to correspond on each margin so that when the pedicle comes to be tubed the points are already there to be matched

Although the amount of subcutaneous fat varies enormously in different patients the depth of the main skin vessels remains constantly fairly superficial, and this allows considerable thinning to be carried out with impunity But no matter how much thinning

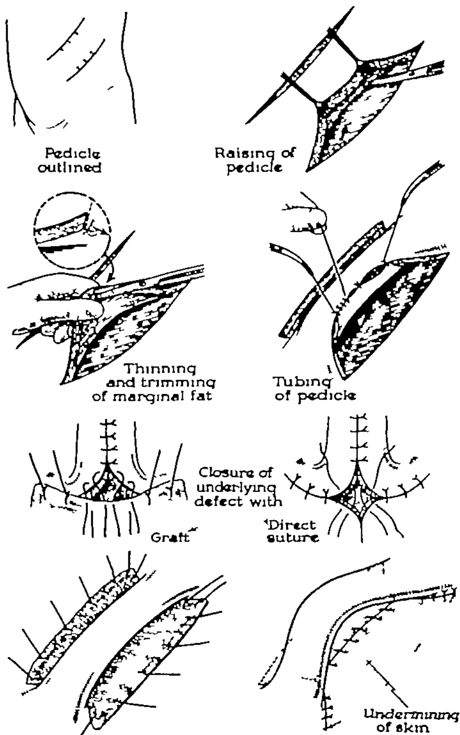


FIG 4 8

Raising an abdominal tube pedicle

is needed the pedicle should be raised initially in the plane between superficial fascia and muscle or aponeurosis, leaving no fat on the resulting raw area This is done because it is technically much easier, gives an initial uniform thickness to the flap, vessels are few and more readily picked up for ligation, and the bed which results takes a free graft much better than would fat The hand holding the flap should be used to judge the amount of thinning required Touch gives a much more accurate measure than vision alone The flap should be elevated over its full length or even a little beyond it and must be thinned uniformly until it tubes readily without tension Trimming off the fat along each margin eases closure of the tube and prevents little herniations of fat between sutures when the flap is tubed Haemostasis must be complete before tubing is begun A continuous "over and over" suture can be employed to tube the pedicle with a few preliminary interrupted sutures using the tattooed matching points before the main suture is begun The interrupted sutures have the effect of distributing tension correctly As each end is approached, the tension increases and tubing should be discontinued as soon as there is any suggestion of difficulty in bringing the skin edges together

With the pedicle tubed the underlying defect if of any size is split-skin grafted The pressure dressing of the graft must be carefully applied to get the necessary immobility and apposition of the graft without being bulky enough to embarrass the circulation of the tube When the tube is small in size the underlying defect is closed by direct suture and the junction of the two axial suture lines is then best closed with a modified three-point suture

During the ensuing 6 weeks it is desirable to get *all* raw surfaces healed and the most difficult areas are at the junction of the graft and the axial suture line of the tube where a tiny granulation tends to persist Ingenuity may be required to keep the surfaces apart so that they can heal but the surgeon should be reluctant to embark on transfer of the tube until healing is complete

Transfer to the carrier (Fig 4, 9)

The usual carrier is the wrist and on it a curved trap-door of skin and superficial fascia which includes the superficial veins is elevated The raw surface which this creates is apposed to the corresponding raw surface left when one end of the pedicle is

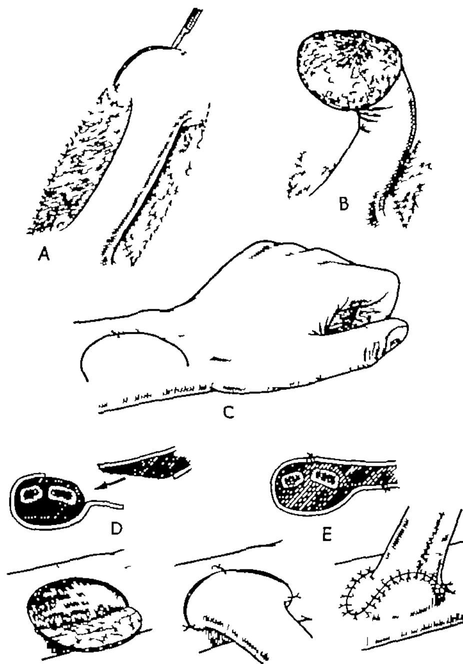


Fig 4, 9

Transfer to the wrist carrier After marking out the line of incision and tattooing matching points (A) the end of the pedicle is raised giving a circular raw surface (B) A semicircular trap-door is outlined (C) on the wrist and raised (D) to give a circular raw area to which the end of the pedicle is sutured (E)

detached From its carrier attachment the pedicle obtains a new blood supply for the next stage of its transfer The raw areas of wrist and pedicle are made to correspond in shape and size so that complete skin closure can eliminate raw surface

The best attachment provides the maximum of raw surface contact and resulting vascular link-up and in this the important factor is the shape of the trap-door The width of the raw surface which is theoretically that of the pedicle, is constant but its shape can vary from a narrow ellipse to a circle As an ellipse approaches the circle in shape its circumference and area both increase and as a trap-door more pointed than a semi-circle creates its own problems the semi-circular trap-door is probably the best shape for the purpose

It is usually stated that in dividing one end of a tube pedicle a straight transverse incision completing the rectangle of the flap should be used but such a straight end sutured to the curved raw area of the carrier creates distortion with tension on the central part of the pedicle and this is something to be avoided A sounder procedure is to make the end of the pedicle semi-circular in shape so that the raw area of the pedicle is virtually a circle, for which a correspondingly circular raw area can be created The trap-door is best made a trifle smaller than the pedicle dimensions would indicate as this positively eliminates pedicle tension A haematoma would prevent the rapid vascular link-up which is aimed at and haemostasis is important

The raw area resulting from the elevation of the end of the tube is either closed by direct suture or, more often, split-skin grafted

The position of the trap-door. According to the plan of transfer the site will be the ulnar or radial aspect of wrist (Fig 4, 10) and it should be placed so that the turning back of the trap-door leaves the raw area in one plane In this way, the trap-door lies smoothly back when suturing is complete and the attachment as a whole runs cleanly off the limb

The other variable is the angle of attachment and consideration of how arm and wrist are going to lie at the next transfer and the angle which arm and pedicle must make as a result should decide this The "hinge" along which the trap-door is raised will be perpendicular to the desired direction of the pedicle

Before detaching the tube it is wise to tattoo suitable points,

e g centre and margins of the pedicle so that fixing sutures to distribute suture line tension can be used The difficult healing point is where the trap-door meets the axial scar of the tube and care in suturing here is advisable

Interval care of the pedicle In the early post operative period the arm wrist and pedicle must be immobilised in an appropriate position It is usual to wait for 3 weeks before the next stage is begun but once healing is complete the patient must be encouraged



FIG 4 10
Attachment of abdominal tube pedicles to wrist carriers showing radial and ulnar attachments

to move to the maximum of his capacity all the upper limb joints, to massage the wrist inset and generally treat the pedicle in a moderately cavalier fashion Physiological delay in preparation for the next stage of transfer can be started as soon as healing is advanced

Tests for adequacy of circulation. Tube pedicle transfers are tedious time-consuming affairs and it is scarcely surprising that various tests have been developed to arbitrarily decide when an inset pedicle has developed an adequate vascular link up to permit detachment of the other end for transfer The vascular link up across the inset can be isolated for testing by clamping off the other attachment of the tube Tests are of two types

1 Measurement of the passage of a substance across the inset and assessment of vascular efficiency in terms of this Atropine injected subcutaneously into the pedicle can be timed for the development of its systemic effects or the appearance of fluorescence of a histamine wheal on the pedicle can be

timed following intravenous injection of fluorescein More recently the disappearance of the radioactive sodium isotope in the form of $Na^{24}Cl$ from an injection site in the tube has also been used

2 Measurement of the clearance rate across the inset of congestion created in a pedicle

The first set of tests in particular measure quite indirectly and rather dubiously those factors which need to be measured, namely the *vis a tergo* of the blood entering the pedicle and the

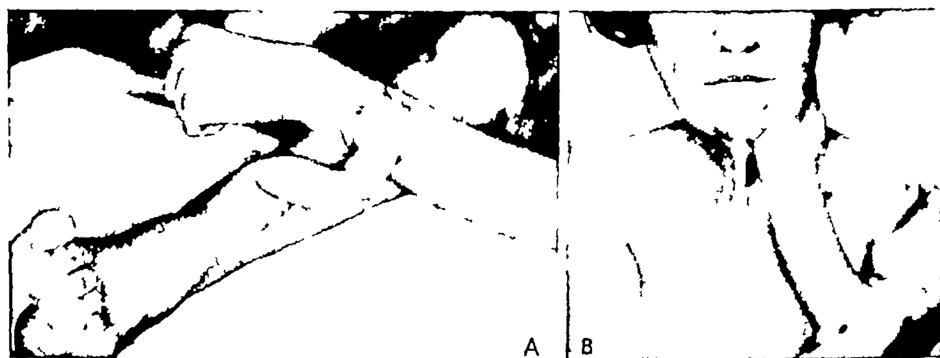


FIG 4, 11

Transfer of tube pedicles on wrist carriers Note in each case the large segment inset to provide a vascular attachment adequate for the next transfer

overall adequacy of the venous drainage The congestion test is a more direct index of vascular efficiency since it more nearly imitates the state of affairs to be present when the tube is actually transferred

It must be stressed that these tests constitute a single piece of evidence only and they must be used in conjunction with a general clinical assessment of the situation

The effect of haematoma A rapid vascular link-up over the maximum of area is desirable in any pedicle inset and the factor most likely to prevent this is a haematoma Haemostasis must be meticulous and a haematoma diagnosed clinically post-operatively should be evacuated if possible Not merely does it prevent vascular link-up, but it gives rise to induration and loss of flexibility

Transfer on the carrier (Fig 4, 11)

This is essentially similar to the wrist inset After severing the remaining abdominal attachment the flap is moved on its

carrier to be inset into part or all of its destination It is not usual to aim at final disposition of the flap on the recipient area at this stage What is aimed at rather is attachment of the free end of the tube to a suitable segment of the recipient area having regard to the need to establish a vascular link up adequate to nourish the flap when it is later detached from the wrist to be completely untubed and inset It is therefore advisable to give the flap as big an attachment as is expedient with positioning of the wrist etc To increase the raw area of the flap the tube is undone as far as required excising the scar of the tubing and thinning appropriately The raw area is measured against the selected segment of the recipient site and an appropriate area of skin is excised Where possible a small trap-door flap can be raised from the recipient site to close off the raw area where tubing of the flap begins again

Completing the transfer

After a further period of 3 weeks the pedicle is removed from the wrist the scar of the tubing is excised and the flap is opened It is found on opening the tube that an axial line of scarring has developed along its centre which prevents it from untubing readily With the tube partially opened it gives the appearance of a well defined layer like deep fascia and only excision or at very least deep multiple longitudinal scoring of this layer will permit the flap to untube completely and spread to its original dimensions When the flap is spread out and thinned if necessary the amount of skin to be excised is defined and removed so that the flap can be sutured in position It is not always safe to complete the transfer and spread the whole pedicle in a single procedure The detached wrist inset may then be set into its final destination leaving the still tubed central segment of the pedicle (Fig 4, 12) to be untubed and inset 3 weeks or so later once both ends have an efficient vascular attachment

The wrist trap-door is sutured back in its original position It is less easy to return to its original situation than one might expect for the trap door will be found to have shrunk somewhat and the several wound edges have to be mobilised to achieve closure A good suture line is often difficult to get but in this time fortunately works wonders in most cases

timed following intravenous injection of fluorescein More recently the disappearance of the radioactive sodium isotope in the form of $Na^{24}Cl$ from an injection site in the tube has also been used

2 Measurement of the clearance rate across the inset of congestion created in a pedicle

The first set of tests in particular measure quite indirectly and rather dubiously those factors which need to be measured, namely the *vis a tergo* of the blood entering the pedicle and the

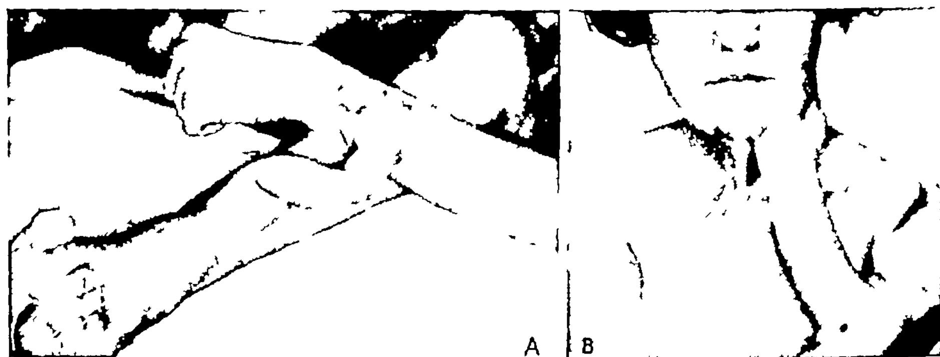


FIG 4, 11

Transfer of tube pedicles on wrist carriers Note in each case the large segment inset to provide a vascular attachment adequate for the next transfer

overall adequacy of the venous drainage The congestion test is a more direct index of vascular efficiency since it more nearly imitates the state of affairs to be present when the tube is actually transferred

It must be stressed that these tests constitute a single piece of evidence only and they must be used in conjunction with a general clinical assessment of the situation

The effect of haematoma A rapid vascular link-up over the maximum of area is desirable in any pedicle inset and the factor most likely to prevent this is a haematoma Haemostasis must be meticulous and a haematoma diagnosed clinically post-operatively should be evacuated if possible Not merely does it prevent vascular link-up, but it gives rise to induration and loss of flexibility

Transfer on the carrier (Fig 4, 11)

This is essentially similar to the wrist inset After severing the remaining abdominal attachment the flap is moved on its



Fig 4 13

Waltzing a tube The post-mastoidectomy defect (A) is closed by the clavicular tube pedicle (B) waltzed (C D and E) to fill the defect (F)

Waltzing a tube

When a tube is being waltzed (Fig 4, 13), the procedures vary from those described for the carrier method only in the siting of the trap-door with a view to achieving the *maximum of movement* in the desired direction commensurate with the minimum of



FIG 4, 12

Double attachment of a tube pedicle prior to final insetting Closure of fistula (A) by acromio-pectoral tube inset into a reception area (B) immediately anterior to the fistula *The double attachment is made by insetting the other* end (C) immediately posterior to the fistula prior to untubing and closure of the defect (D)

kinking and tension during both the current and the subsequent transfer

THE DIRECT FLAP

The direct flap is raised with or without preliminary delays, according to its dimensions, and directly sutured to the defect The raw area left when the flap is raised is closed by direct suture if small, otherwise a split-skin graft is applied Meticulous planning in reverse is necessary to avoid the tension, kinking and



FIG 4, 13

Waltzing a tube The post mastoidectomy defect (A) is closed by the clavicular tube pedicle (B) waltzed (C D and E) to fill the defect (F)

Waltzing a tube

When a tube is being waltzed (Fig 4, 13), the procedures vary from those described for the carrier method only in the siting of the trap-door with a view to achieving the maximum of movement in the desired direction commensurate with the minimum of



FIG 4, 12

Double attachment of a tube pedicle prior to final insetting Closure of fistula (A) by acromio-pectoral tube inset into a reception area (B) immediately anterior to the fistula The double attachment is made by insetting the other end (C) immediately posterior to the fistula prior to untubing and closure of the defect (D)

kinking and tension during both the current and the subsequent transfer

THE DIRECT FLAP

The direct flap is raised with or without preliminary delays, according to its dimensions, and directly sutured to the defect The raw area left when the flap is raised is closed by direct suture if small, otherwise a split-skin graft is applied Meticulous planning in reverse is necessary to avoid the tension, kinking and



FIG 4, 13

Waltzing a tube The post mastoidectomy defect (A) is closed by the cla icular tube pedicle (B) waltzed (C D and E) to fill the defect (F)

shearing which are so disastrous, and also to ensure that the patient is given as comfortable a position to maintain as possible

The direct flap should aim to get as much as possible of the flap in contact with the defect at the initial transfer leaving the minimum to be attached later and a good principle is to make the flap so that any tendency to movement pulls the flap on to the defect rather than away from it In limb flaps the effect should be to wrap the flap around the limb

Even in the direct flap there is always a pedicle though it is frequently very short compared with the remainder of the flap The longer the pedicle the greater the range of permissible mobility of recipient on donor site and the greater the safety factor against tension, etc On the other hand a long pedicle reduces the length-breadth ratio and in effect narrows the flap from a vascular point of view Those seeming irreconcilables can both be met on occasion by making the base of the pedicle broader than the segment which is to be inset so that a broad pedicle is combined with a reasonably long one

Avoidance of raw areas (Fig 4, 14)

As already described pedicles are often tubed to eliminate raw areas Similarly it is desirable, though not always possible, to eliminate raw areas during other types of flap transfer—excluding those of face—and this can be done either by using a trap-door or a split-skin graft, or a combination of the two

Use of the trap-door A reception flap from the margin of the recipient site is raised and sutured to the flap and/or skin graft Such a trap-door flap should be as short as possible as it consists of tissue of the defect and tends to be scarred and avascular

Use of the split-skin graft When a trap-door is not possible the split-skin graft covering the flap donor site can be made longer so that it lines the pedicle segment of the flap where it would otherwise be raw

Despite the use of these devices greater or smaller raw areas frequently persist and in difficult situations are virtually inevitable

Division of the flap

Whether a reception flap or split-skin graft have been used an acute angle of fibrous tissue is nearly always built up at the junctio

of recipient area and flap (Fig 4, 15) so that the flap when divided does not inset naturally into the remaining part of the defect The flap as a result has to be dissected off the defect and thinned

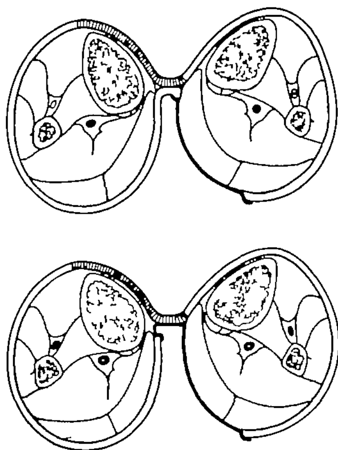


Fig 4, 14

Methods of avoiding raw areas during the transfer of a direct flap A reception flap when available may be raised from the margin of the recipient area or the skin graft used to cover the donor site of the flap may be extended to line the pedicle segment

a little at the same time excising the fibrous tissue of the angle to allow it to sit nicely into the remaining defect Such dissection though minimal does have an adverse effect on the vascular supply and marginal necrosis of the flap is apt to result Because of this it is often advisable to delay the flap before dividing it completely though a delay causes the usual induration which follows any incision and a neat suture line when the flap is finally inset may

shearing which are so disastrous, and also to ensure that the patient is given as comfortable a position to maintain as possible

The direct flap should aim to get as much as possible of the flap in contact with the defect at the initial transfer leaving the minimum to be attached later and a good principle is to make the flap so that any tendency to movement pulls the flap on to the defect rather than away from it In limb flaps the effect should be to wrap the flap around the limb

Even in the direct flap there is always a pedicle though it is frequently very short compared with the remainder of the flap The longer the pedicle the greater the range of permissible mobility of recipient on donor site and the greater the safety factor against tension, etc On the other hand a long pedicle reduces the length-breadth ratio and in effect narrows the flap from a vascular point of view Those seeming irreconcilables can both be met on occasion by making the base of the pedicle broader than the segment which is to be inset so that a broad pedicle is combined with a reasonably long one

Avoidance of raw areas (Fig 4, 14)

As already described pedicles are often tubed to eliminate raw areas Similarly it is desirable, though not always possible, to eliminate raw areas during other types of flap transfer—excluding those of face—and this can be done either by using a trap-door or a split-skin graft, or a combination of the two

Use of the trap-door A reception flap from the margin of the recipient site is raised and sutured to the flap and/or skin graft Such a trap-door flap should be as short as possible as it consists of tissue of the defect and tends to be scarred and avascular

Use of the split-skin graft When a trap-door is not possible the split-skin graft covering the flap donor site can be made longer so that it lines the pedicle segment of the flap where it would otherwise be raw

Despite the use of these devices greater or smaller raw areas frequently persist and in difficult situations are virtually inevitable

Division of the flap

Whether a reception flap or split-skin graft have been used an acute angle of fibrous tissue is nearly always built up at the junction

Practice of the Method in Various Sites

The upper limb In major resurfacing of the arm and hand the usual donor site is the trunk and the flap must be planned so that with the limb in a comfortable position the flap wraps round the limb In the forearm the limb is most comfortable in the neutral position extreme pronation or supination is difficult to maintain Because of this the base of the flap is best made

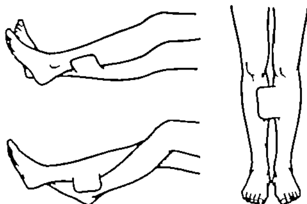


FIG 4, 16

The classical cross leg flap positions

superior where the defect is radial and inferior where the defect is ulnar so that in each case the natural tendency of the limb to move downwards and outwards from the trunk wraps the flap round the recipient site rather than pulling it away from it

Similar considerations arise in flaps applied to the wrist and dorsum of hand though on occasion a direct flap from one forearm to the other hand is used and then the broad principles described for cross-leg flaps apply Cross-arm flaps together with the other types of flap used in Hand Surgery are discussed in detail in Chapter Seven

The lower limb The direct flap used in the leg and foot is the cross-leg flap where the skin of one leg is transferred as a direct flap to cover a defect of the other leg the appropriate parts of the limbs being approximated by suitable positioning (Fig 4, 16) The donor sites are limited to

1 **Middle two-thirds of the length of tibia.** In this segment the site must *not* include the skin directly over the tibia lest failure of the split skin graft applied to the secondary

not be achieved initially It is fortunately remarkable how the flap settles in with time and the scars improve in appearance

A delay used in this context does of necessity leave the limbs in their immobile position for a further week or so, and this may sometimes be undesirable When the pedicle has a residual raw area too a delay means a fresh incision in an area which cannot be

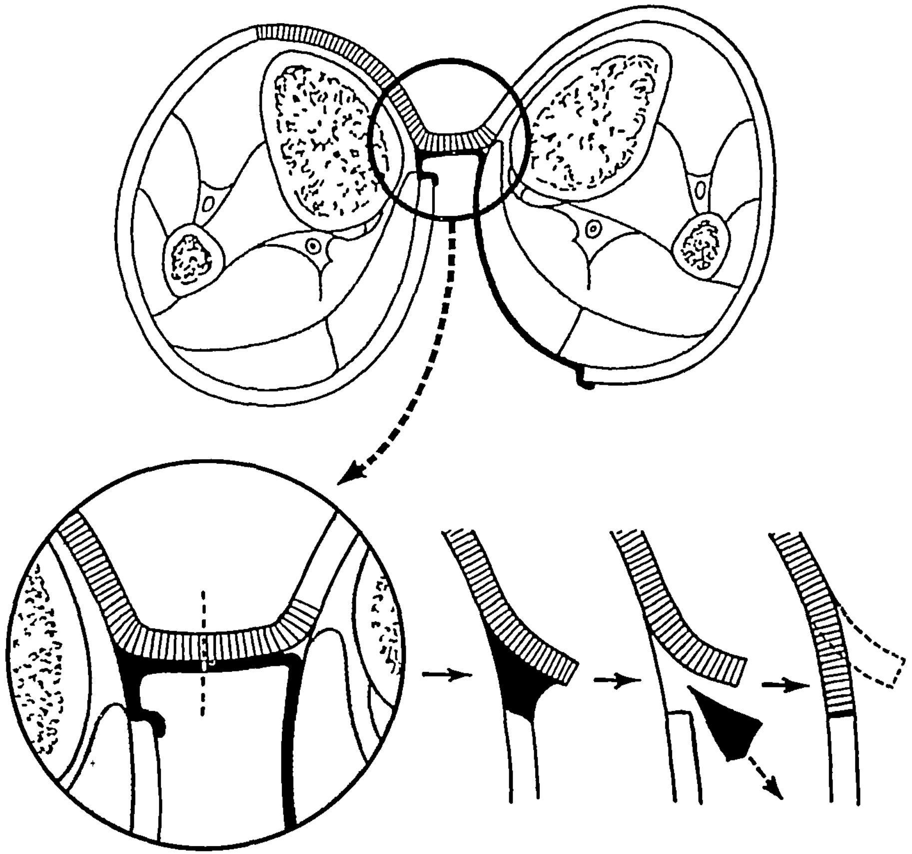


FIG 4, 15

The angle of fibrous tissue usually built up at the junction of the flap and the recipient area which has to be excised to allow the flap to sit into the remainder of the defect The dissection involved in this has an adverse effect on the blood supply of the flap margin

made surgically clean and one which an unavoidably awkward position may make difficult to keep as clean post-operatively as one would wish An alternative then is to detach the flap completely without attempting an inset This has the same effect as a delay and while waiting to inset the remainder of the flap in 7–10 days limbs, fingers, etc , can be mobilised as required

Practice of the Method in Various Sites

The upper limb In major resurfacing of the arm and hand the usual donor site is the trunk and the flap must be planned so that with the limb in a comfortable position the flap wraps round the limb In the forearm the limb is most comfortable in the neutral position extreme pronation or supination is difficult to maintain Because of this the base of the flap is best made

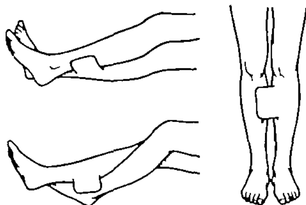


Fig 4, 16

The classical cross-leg flap positions

superior where the defect is radial and inferior where the defect is ulnar so that in each case the natural tendency of the limb to move downwards and outwards from the trunk wraps the flap round the recipient site rather than pulling it away from it

Similar considerations arise in flaps applied to the wrist and dorsum of hand though on occasion a direct flap from one forearm to the other hand is used and then the broad principles described for cross-leg flaps apply Cross arm flaps together with the other types of flap used in Hand Surgery are discussed in detail in Chapter Seven

The lower limb The direct flap used in the leg and foot is the cross-leg flap where the skin of one leg is transferred as a direct flap to cover a defect of the other leg the appropriate parts of the limbs being approximated by suitable positioning (Fig 4, 16) The donor sites are limited to

1 **Middle two-thirds of the length of tibia** In this segment the site must *not* include the skin directly over the tibia lest failure of the split skin graft applied to the secondary

defect should leave bare tibia to complicate the transfer Usually flaps are outlined just behind the subcutaneous surface of tibia based in the direction found to suit best when the procedure is planned

2 **Lower anterior thigh.** To use this site successfully the defect requiring the flap must be in the vicinity of the heel or ankle (Fig 4, 18C) since in all but the acrobatic these are the only areas capable of ready approximation to the donor site on the thigh Indeed even with the ankle and heel the position required of the patient takes a degree of agility seldom found in the average adult The site as a result has very limited usefulness

In theory a proximally based flap should have a more normally directed vascular flow but in the distally based flap the main direction of the vascular flow remains along the axis of the limb even if reversed in direction and therefore the direction of the base is not of great significance Disruption of normal flow is likely to be greater in the side-based flap

Unless the length-breadth ratio is unusually favourable it is advisable to delay cross-leg flaps and the delay can include as a stage elevation of the flap so that perforating veins may be divided The donor leg of the flap should be avoided as a source of the split-skin graft which covers the secondary defect, for the dressing of the donor site will naturally raise the venous pressure of the leg and such a rise, however small, tends to increase congestion of the flap and helps to set off the cycle of congestion, oedema, kinking, etc , unless extreme care is exercised

IMMOBILISATION DURING FLAP TRANSFER

When a transfer is to the upper limb or head and neck, elastoplast must be relied on in conjunction with sand-bags, pillows, etc , to keep the parts suitably positioned (Fig 4, 17) When the transfer is to the lower limb, whether tube pedicle on the wrist or cross-leg flap, immobilisation by plaster of Paris is much more effective for it takes altogether from the patient the onus of maintaining his position Plaster does nevertheless impose its own discipline on the surgeon and it must be used with care

The plaster of Paris can be applied at the time of operation,

but prefabrication has undoubted advantages These procedures cross-leg flaps especially are among the more exacting in plastic surgery at all phases—in planning in execution and in post-operative care The position of the limbs must be maintained from the moment of inserting the first suture joining flap and



FIG 4, 17

The method of fixing the arm during transfer of a direct flap to the upper limb

recipient site to the final division of the pedicle 3–4 weeks later Holding the limbs during suture and subsequent immobilisation is an unrewarding and most fatiguing task With ample able bodied assistance application of the entire plaster cast at the time of operation may be feasible and satisfactory but when such assistance is minimal all concerned will welcome anything which can speed up the process of post-operative immobilisation Speeding up is best achieved by prefabricating the plaster cast

The prefabricated plaster Prior to the operation and with the limbs in the position to be maintained post-operatively to permit

accurate moulding of the plaster to the muscular contours, lengths of encircling plaster are applied at strategic points so that, strutted together post-operatively (Fig 4, 18), e g , with lengths of broom-handle, the whole system is held rigidly immobile in its correct position Added lengths of plaster and struts may be used but seldom are more than three or four needed The flap is best

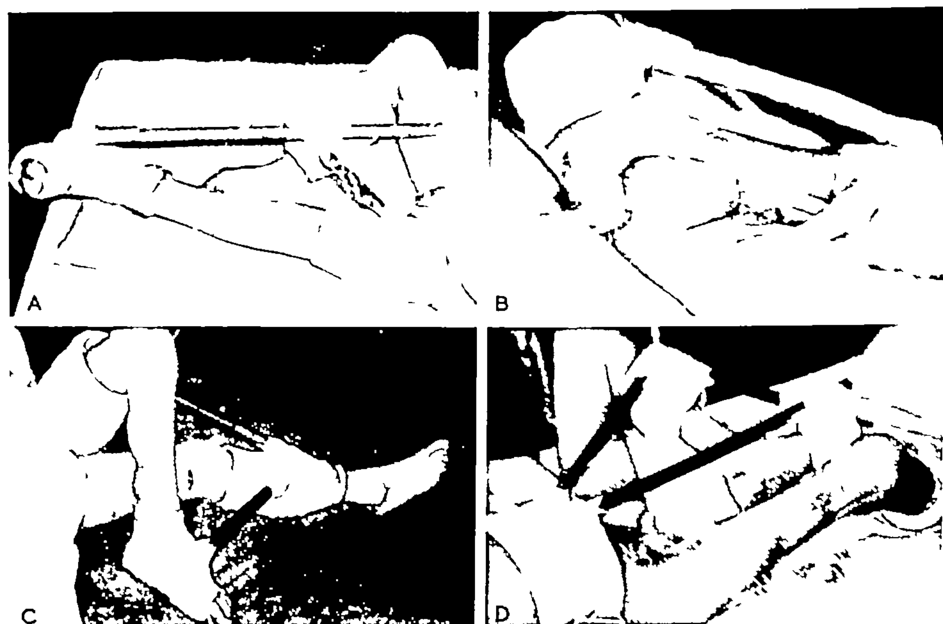


FIG 4, 18

Examples of prefabricated plaster fixation during cross-leg flap transfers

left exposed while the struts are being applied so that its position can be watched carefully, the slight contamination with plaster has not been significant In this situation one of the transparent plastic dressings can usefully be employed to protect the suture line

With a pedicle on the wrist the arm plaster is the really important though most difficult segment of the system and a *very* carefully applied plaster which includes the hand to the distal transverse crease, well set back from the pedicle inset is used

The tendency is for the arm to pull from the leg and so slide up the plaster and to prevent this a mean must be sought between the tight plaster which will give rise to swelling and circulatory embarrassment and the slack one which allows movement

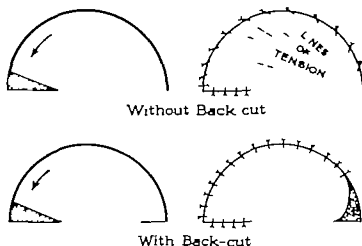
One way of getting round the difficulty is to have the axis of pull of the arm at right angles to the pull of the pedicle A strong

transverse bar incorporated in the plaster across the palm also gives the patient something to grip to prevent sliding

ROTATION AND TRANSPOSED FLAPS

To cover a primary defect it may be possible to move the adjoining tissue any secondary defect being closed by direct

ROTATION FLAP



TRANSPOSED FLAP

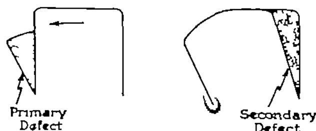


Fig 4, 19

Diagrams of rotation flaps with and without back-cut and transposed flap

suture or free skin graft When the tissue is rotated into the primary defect the flap is called a **rotation flap** moved laterally into the defect it is called a **transposed flap** Most flaps combine both principles in varying degrees and a particular flap may be called by the principle which predominates (Fig 4 19)

These flaps cannot adequately be described in print, even with a profusion of illustrative examples (Figs 4, 20, 21, 22 and 23),

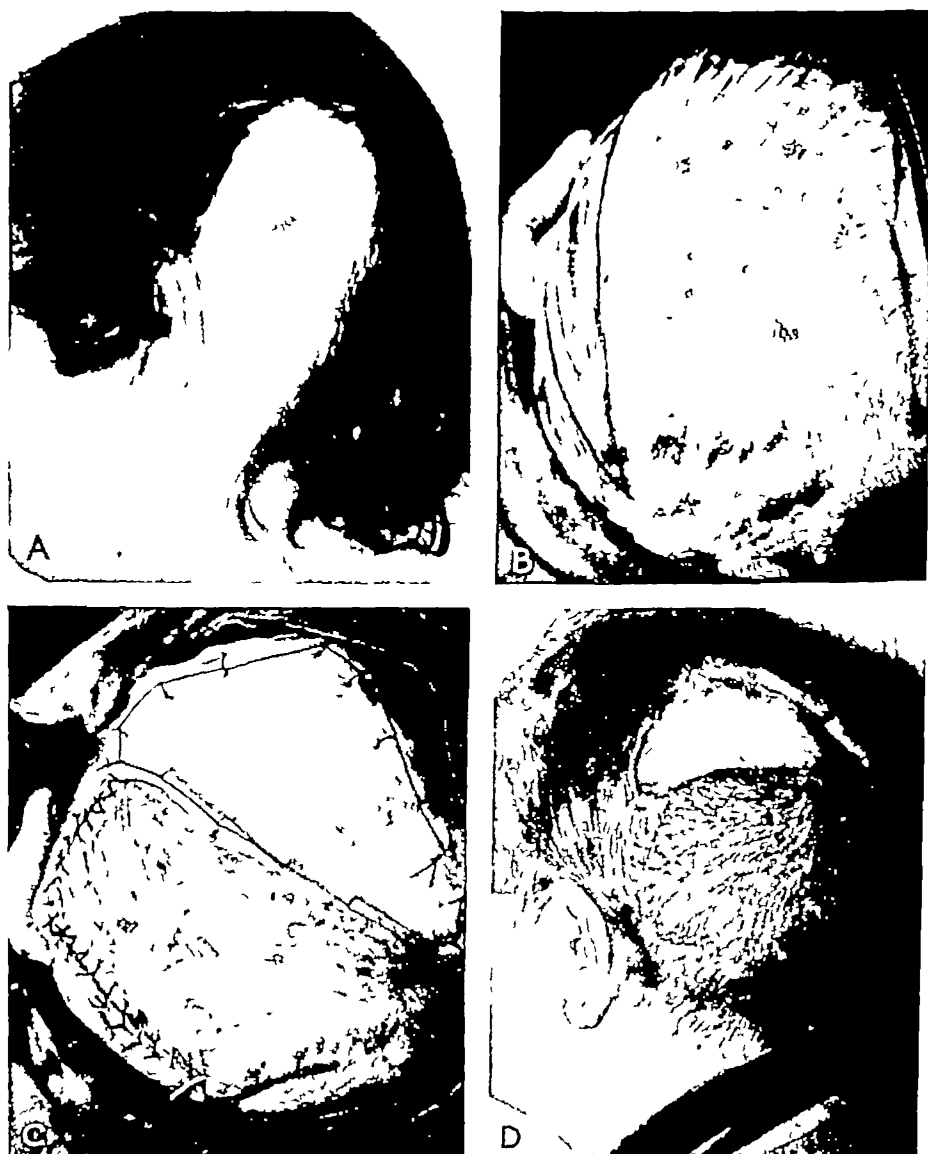


FIG 4, 20

Transposed flap used following excision of rodent ulcer involving outer table of skull Flap outlined after triangulation of defect to be left when the ulcer (A) is widely excised (B) The flap transferred (C) and the secondary defect covered with a split-skin graft The final result (D)

for every flap is an individual problem In the face particularly, judgment in selection and imagination in design come with the

experience born in surgical apprenticeship Present discussion is concerned to explain the principles underlying the construction of

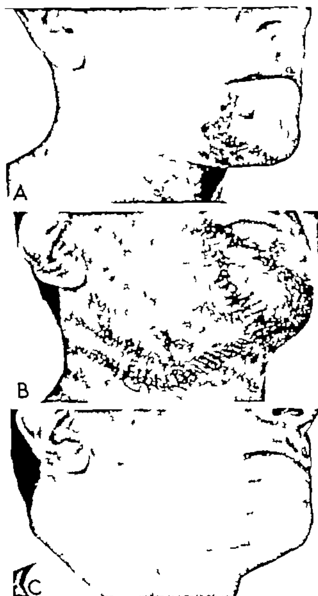


Fig 4, 21

Rotation flap without back-cut following excision of haemangioma

such flaps They depend to a considerable extent on the elasticity of the tissues but in planning this should not be relied on rather should it be considered as an added insurance They are

These flaps cannot adequately be described in print, even with a profusion of illustrative examples (Figs 4, 20, 21, 22 and 23),

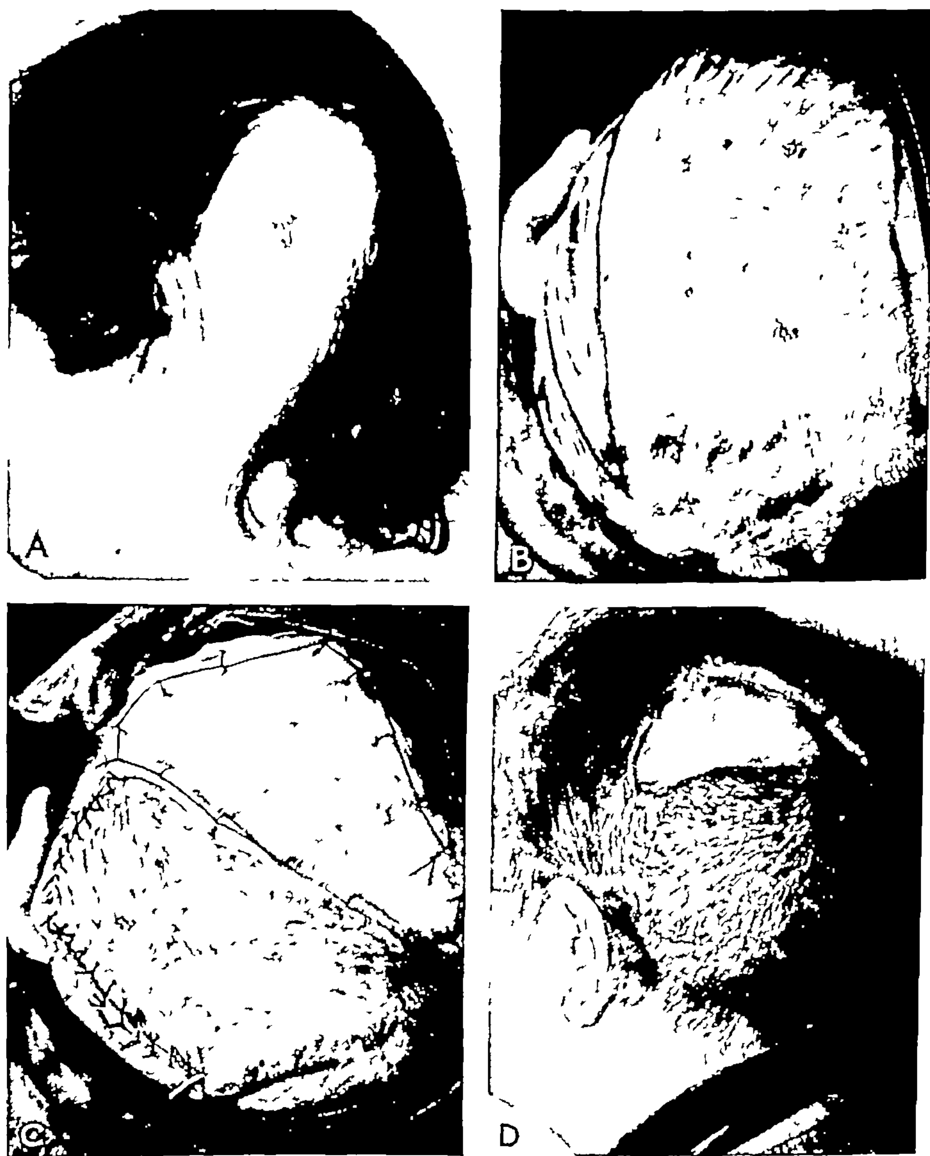


FIG 4, 20

Transposed flap used following excision of rodent ulcer involving outer table of skull Flap outlined after triangulation of defect to be left when the ulcer (A) is widely excised (B) The flap transferred (C) and the secondary defect covered with a split-skin graft The final result (D)

for every flap is an individual problem In the face particularly, judgment in selection and imagination in design come with the

distributed evenly all along the suture line It follows that the larger the circle of the flap the longer is the line along which the tension difference can be distributed and the smaller the difference at any particular point

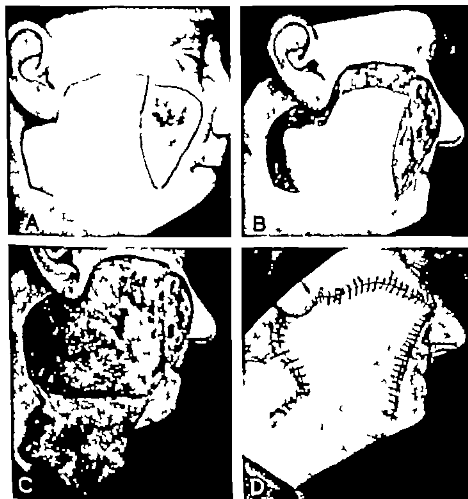


Fig 4, 23

Combined rotation—transposed flap used following excision of a pre malignant keratosis of cheek. Flap outlined (A) raised (B C) and transferred (D) with direct suture of the secondary defect

A *pure* rotation flap has no secondary defect but often depending on the laxity of the tissues and the degree of rotation required the primary defect cannot be closed purely by redistributing the tension and a further incision has to be made to allow the flap to move laterally as well as rotate into the defect. Where the curve of flap and defect makes a half circle the incision is made as a

geometrical manoeuvres and treated as such are more likely to be trouble-free in practice

Principle of rotation (Fig 4, 24) As the flap will be rotated into position it should in theory be the arc of a circle of which the

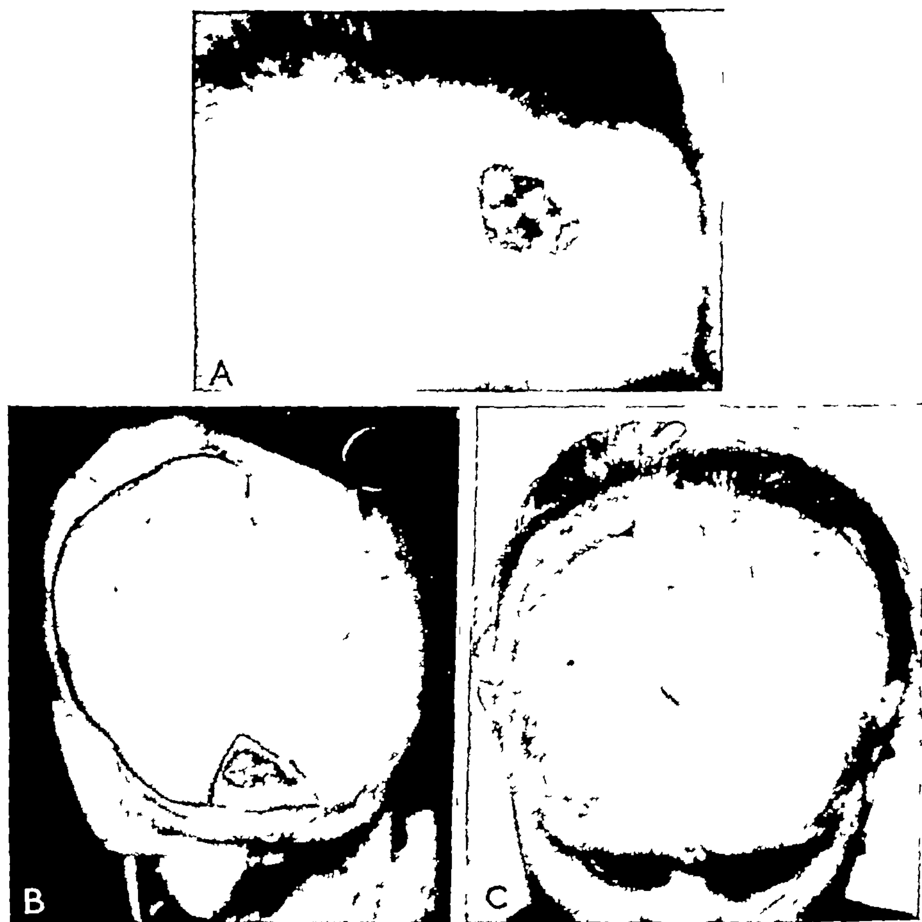


FIG 4, 22

Rotation flap with back-cut used following excision of rodent ulcer involving outer table of skull Flap outlined (B) after triangulating the defect to be left after excision of the ulcer (A) Final result (C) with the secondary defect split-skin grafted

primary defect is a segment, flap and defect together making a half-circle The defect is thus approximately triangular in shape and the narrower the triangle the less does the tissue have to rotate to fill the defect With the flap rotated into the defect and sutured in place there is a difference of tension on the two sides of the suture line and ideally this difference of tension is

The vascular limitations of local flaps

When a local flap is moved there tends to be a line of tension along the base or obliquely across the flap and this if excessive, is extremely prone to cause necrosis of the tissue beyond it A back-cut will usually eliminate the tension line and allow the flap to move readily into the defect but it must be recognised that the back-cut also reduces the vascular area of the base and thus the circulatory reserve

These two factors—vascular area and tension—must always be balanced and to know just how much one may be reduced to eliminate the other in a particular situation is a measure of experience Probably tension is a more potent producer of massive necrosis than reduction of vascular area The enhancement of vascular efficiency produced by a delay tends to be offset by the fibrosis which it causes particularly if the delay includes elevation of the flap for the flexibility of a flap always helps to reduce tension

Planning the flap (Fig 4, 25)

It must be stated at the outset that the guiding principles to be laid down apply to rotation and transposed flaps in their classical forms and do not necessarily apply to many of the flaps used in certain parts of the head and neck These will be discussed separately

The first step with either type of flap is to **triangulate the defect.** The defect must be capable of being outlined as a triangle with two sides approximately equal and this may necessitate the sacrifice of normal tissue to make the triangle A defect which for any reason cannot be triangulated is seldom suitable for a standard local flap As a rule the two equal sides of the triangle are longer than the third which forms the base and in visualising the procedure and the flap appropriate to it the defect must be thought of as being closed by moving one of the equal sides as a side of the flap across to the other

With a long narrow defect triangulation may be planned to place the apex at either end and which end should be apex and which base may not be immediately apparent The base of the flap will be alongside the apex of the triangle and so the end should be chosen as apex which will provide the better flap base from the point of view of blood supply line of scar and tissue availability

back-cut along the diameter line This enables the flap to move by a combination of rotation and transposition into the defect

This back-cut creates a secondary defect which is closed where possible by direct suture, failing this by a free skin graft

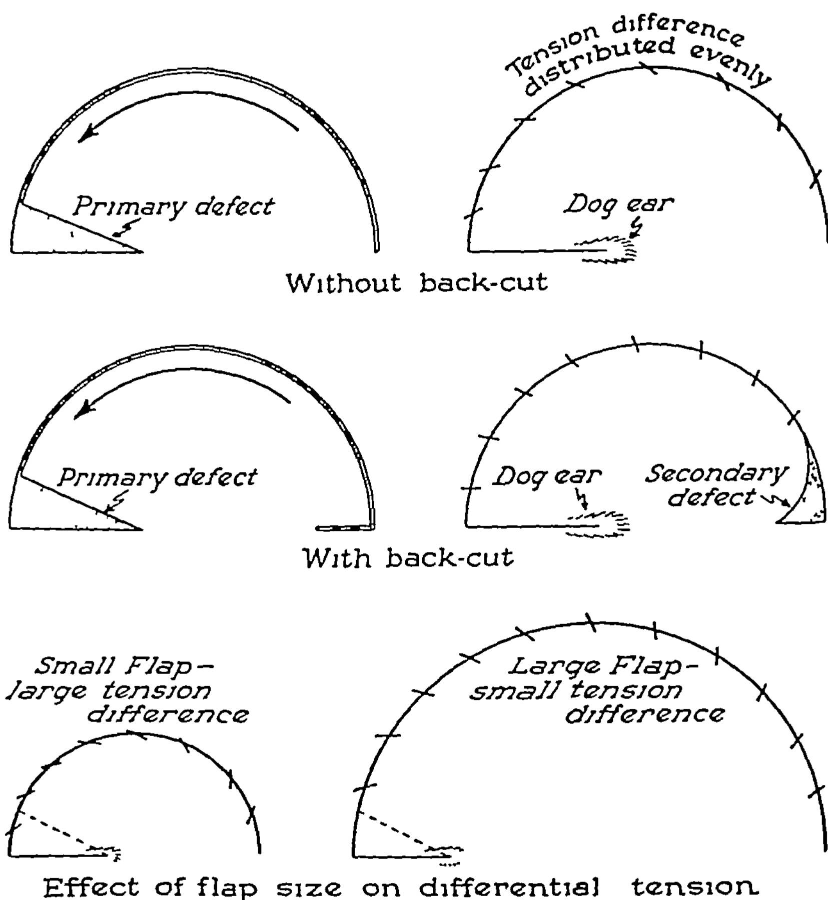


FIG 4, 24

Diagrams of rotation flaps showing the effect of the back-cut and the influence of the size of the flap on tension difference

Principle of transposition Even in its purest form the transposed flap does pivot on an axis and so does rotate, but the major movement is lateral The primary defect is again triangular and the rectangular flap constructed along one of its sides moves laterally when transposed into the defect One purpose of the manoeuvre is to avoid tension of the suture line closing the primary defect and so the secondary defect cannot be directly sutured since this would recreate the very tension the flap was designed to avoid It must therefore be closed either by a free skin graft or by a further plastic procedure which will permit closure without tension

close the defect the distance from the pivotal point to the far point of the triangle must equal the diagonal length of the flap from the pivotal point

Before any incision is made the pivot point must be clearly defined and the distance from the pivot to each point of the flap compared with its estimated distance to the same point when transposition is complete Where the distance before transposi

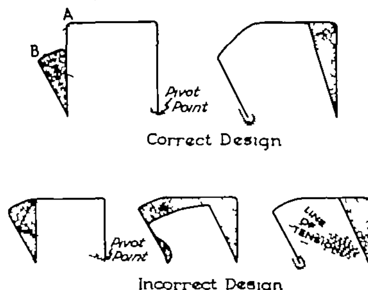


Fig 4, 26

The design of a transposed flap Compare the well-designed flap where the distance from the pivot point to A equals that to B and the transfer is consequently without tension and the incorrectly designed flap where the distances are unequal because the flap is too short and the transfer can only be achieved with tension

tion is shorter there will be a line of tension along that line when the flap is transposed The diagonal length of the flap from the pivot point in the square flap is the one particularly liable to be short The distances can be equated in two ways

1 *Initial design* The flap can be made longer than the side of the triangulated defect so that its actual diagonal length before and estimated diagonal length after transfer are equal and the actual shape and dimensions of the flap can be similarly decided by considering actual lengths before and estimated lengths after

This is the best method and the one to be used in planning the flap If however it should be found when the flap has

With the triangle defined, it may at once be obvious from which side the flap will come. If there is doubt, two factors will decide

1. The side with most tissue available is likely to provide the best flap
2. The anatomical distribution of blood vessels may clearly favour one side

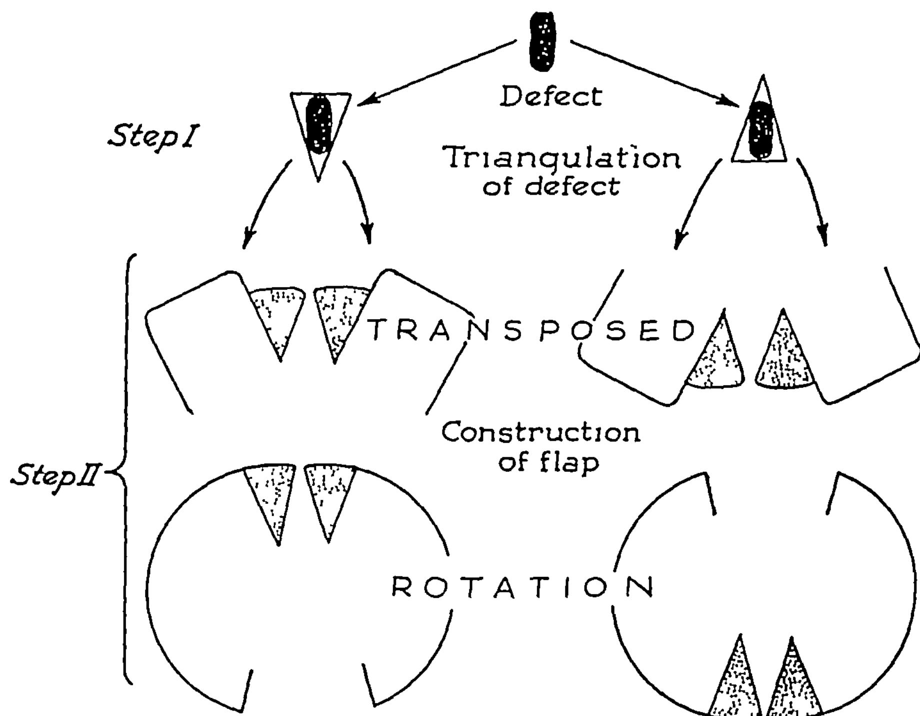


FIG 4, 25

The steps in planning a flap
Step I selects the direction of the base of the flap
Step II selects the side of the defect from which the flap is to be moved

The flap must next be outlined and the principles of construction depend on whether it is to be transposed or rotated

The transposed flap (Fig 4, 26)

Though the ideal length-breadth ratio varies with the site, except in the head and neck the flap should be approximately square and in a difficult situation its dimensions should be even more favourable

The classical shape then is square, and in planning it must first be recognised that the point around which the flap will pivot in moving is *not* the apex of the triangle, but rather the other side of the base of the flap. From this it follows that if the flap is to

mid way between the apex of the triangular defect and the end of the back-cut and the distance from this point to each point of the flap must equal its distance to the point to which it will be sutured

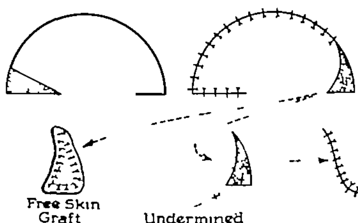


Fig 4, 27

Methods of closing the secondary defect following transfer of a rotation flap by free skin grafting and direct suture

after rotation. The pivot of the rotation flap cannot be pin pointed with the accuracy possible in the transposed flap for the rotation flap does rely to some extent on the flexibility of the tissues It is because of this that it generally works best when the skin is lax and flexible

Outside the head and neck the secondary defect is routinely split skin grafted and in actual practice suturing of the flap is stopped as soon as tension is clearly present and the graft is applied

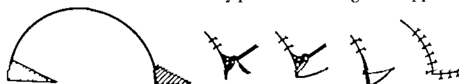


Fig 4, 28

A method of avoiding a secondary defect which can sometimes be used when the skin is lax and tissue available in consequence Fig 5, 18 shows the method in practice

In the head and neck the secondary defect is usually closed by direct suture with the proviso that such closure must not create tension along the base of the flap sufficient to jeopardise its blood supply If direct closure is impossible a graft must be used.

The problem of the secondary defect left when the flap is rotated can sometimes be solved in quite a different way (Fig 4 28)

been cut that the length is inadequate and a tension line will result, an alternative but on the whole less satisfactory device must be used, namely the back-cut

2 *The back-cut* As the flap has been cut its length is fixed and so the point of pivot must be altered to reduce the discrepancies of length and a back-cut achieves this Though it does reduce tension it must be remembered that it also reduces vascularity and so should be as small as possible Sometimes it proves possible to reduce the tension without significantly reducing the vascularity by cutting only the actual tissue responsible for the tension leaving at the same time the blood vessels intact In skin with a good thickness of superficial fascia section of the skin alone may give enough relaxation, while in the scalp cutting the galea aponeurotica may have the same result In the face and neck such differential section is seldom feasible, but fortunately blood supply and tissue availability are usually so good that the problem is less likely to arise in an acute form

The transposed flap is especially useful where a secondary graft is not contra-indicated for cosmetic reasons and so it is used mainly outside the face With it the size of the secondary defect approximates in area to the primary defect and it is covered with a split-skin graft Any attempt to close the secondary defect by direct suture destroys the whole point of the flap transfer for the reason already given

The rotation flap (Fig 4, 27)

The classical rotation flap has a near-circular curve and, used with or without a back-cut along the diameter of the semi-circle, the curve of the flap is able to rotate along the corresponding curve of the other side of the incision outlining the flap It is sutured in its new position with a degree of differential tension, but when a back-cut is needed in addition, as it frequently is, a triangular secondary defect is opened up and the flap really then combines rotation and transposition With the movement of curve on curve there is no defect in the region of the actual flap except at the back-cut The larger the flap is made the less the difference of tension at each point of the flap and most difficulties arise from planning on too small a scale rather on too large

The point around which the flap pivots lies approximately

returned whence it came It is fortunate that the copious vascular pattern permits the carrier segment to be left raw on its deep surface without fear of disastrous sepsis for the narrowness of

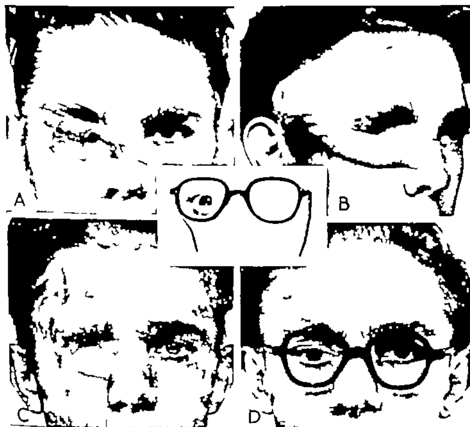


Fig 4, 29

A pedicled flap based on the superficial temporal vascular pattern The post traumatic scarring with loss of eyeball and severe damage to eyelids (A) is replaced by the flap (B) the forehead defect being split-skin grafted With the carrier segment returned to its original site the final result is shown without (C) and with (D) the prosthesis (inset)

these flaps relative to their bulk would make tubing impossible

Where the defect left by raising the flap cannot be closed by direct suture a split skin graft is used for temporary cover and this is removed in due course when the carrier segment is returned to its original site The graft covering the donor site of the transferred segment is usually left as a permanency

Flap planning

With a piece of jaconet shaped to represent the proposed flap and its pedicle held in correct position the flap is transferred to

which is best understood by considering the relative wound lengths The length of the flap is less than that of the wound to which it has to be sutured and the two lengths can be equated either by increasing the length of the flap side, which is the effect of the back-cut, or reducing the length of the outer line of the wound to make it equal the length of the flap Excising a triangle of tissue opposite where the back-cut would normally be has just this effect and is feasible when there is enough tissue available to allow excision In the event the flap is rotated without back-cut and as suturing proceeds it becomes obvious that there is some redundant tissue on the outer side of the suture line and eventually a dog-ear develops, excision of which leaves the two sides equal in length It is only in the head and neck that there is spare tissue available to allow this method to be used

The dog-ear of the triangulated defect

If the pivoting took place round the apex of the triangulated primary defect the resulting suture line would be quite flat but with the pivot point elsewhere both in the rotated and transposed flap there tends to be a dog-ear left at the apex of the triangle when the flap is moved Though it may be possible to deal with this in the usual way at the time of flap transfer, it should always be left for subsequent excision if its removal would in any way jeopardise the blood supply of the flap

FLAPS OF HEAD AND NECK

Although classical local flaps are often used in the head and neck the extremely rich vascular pattern coupled with a laxity of tissue greater than elsewhere in the body permit the planning and execution of flaps with scant regard for the usual requirements A common type is the long narrow pedicled flap based on a known vascular system

Examples are the temporal flap based on the superficial temporal vessels (Fig 4, 29), and the Indian forehead flap based on the supra-orbital vessels (Fig 4, 30)

In most of these the greater part of the flap is used as a carrier of the terminal segment which alone is set into the defect Three weeks suffice for the inset segment to establish its vascular supply locally, the flap is divided and the unused carrier segment is

carrier segment the flap should be broadened and thickened to allow of maximal blood supply For the purposes of flap thickness the head can be divided into the vault of the skull as far as the margins of the galea aponeurotica where the blood supply is entirely marginal and the routine plane of dissection is the loose areolar tissue deep to the galea and the remaining skin which of course has an additional deep blood supply As a result delay of a scalp flap need never include elevation

In the forehead the terminal flap may safely be made thin enough to leave the frontalis muscle behind and in the face and neck it may include the minimum of fat but in both instances it should thicken fairly rapidly to the more usual plane of dissection In the neck this plane is best deep to platysma and includes as much of the superficial venous system as possible

Returning the carrier segment

During the 3 weeks the carrier segment tends to tube itself in two distinct ways by fibrotic contraction of the raw surface and by marginal epithelialisation When returning it to its original site the fibrous tissue must be excised completely to undo the tubing and to get the best suture line the marginal epithelium should also be removed Even so the flap tends to remain a trifle narrower than when it was originally raised and when suturing it back in position after removing the temporary graft the scalp may have to be mobilised quite widely to bring the skin edges readily together This is most likely to occur if the graft has been applied with the scalp in the naturally retracted position it assumes when the flap is raised It is possible to overcome retraction of the scalp by suturing the temporary graft under slightly greater than normal tension This reduction of the grafted area to a minimum makes the subsequent replacement of the flap much more straightforward and free of tension

Following division and return of the carrier segment the insetting of the transferred segment of the flap is completed and as in the direct flap a little thinning of the margin may be necessary to allow it to sit neatly into the defect

Flaps based either on the superficial temporal or supra orbital vessels tend to be the most useful in the repair of sizeable defects of the face above the level of the mouth—generally of the nose cheek and lower eyelid

make sure that it is capable of reaching its destination and the jaconet shape is then used to outline the definitive flap Time and care spent on this step will prevent the disaster of the flap



FIG 4, 30

A forehead flap based on the supra-orbital vascular pattern The scarring (A), the end result of a very extensive molluscum sebaceum, is replaced by the flap (B and C), the forehead defect being closed by direct suture incorporating Z-plasties Final result (D)

which only reaches its destination with difficulty or not at all

Flap transfer

The precise thinness of tissue required in the defect can often be duplicated in the flap with safety, so abundant is the blood supply, but in passing from the part of the flap to be inset to the

HYNES W & MACGREGOR A G (1949) The use of fluorescein in estimating the blood flow in pedicled skin flaps and tubes *Brit J plast Surg* 2, 4

Direct flaps

BRAITHWAITE F & MOORE F T (1949) Skin grafting by cross leg flaps *J Bone Jt Surg* 31B 228

BROWN D O (1943) Repair of limb wounds by the use of direct skin flaps *Brit J Surg* 30 307

CONVERSE J M (1948) Plastic repair of the extremities by non tubulated pedicle skin flaps *J Bone Jt Surg* 30A 163

The first point to be considered in planning is whether the skin cover is to be hairy or not for this will decide whether scalp or forehead must provide the skin Thereafter the appropriate pedicle can be selected using jaconet to give the exact outline A supra-orbital based flap works well for symmetrical nasal defects, defects of one side can be covered with either type—supra-orbital or temporal When the defect involves cheek, either alone or with part of the nose, the temporal flap is usually more satisfactory as the length of pedicle gives the flap a longer reach

While it is often necessary to provide lining as well as skin cover the methods used to provide such lining are beyond the scope of this book and will not be discussed further

Flaps are often required to repair the defects which follow excision of neoplastic lesions, simple, premalignant and malignant, which are unsuited for repair by direct suture or free skin graft They may also be used to replace a free skin graft used for primary repair which is unsatisfactory cosmetically This subject will be discussed in more detail in Chapter Five

In acute trauma, as described in Chapter One, flaps have a very limited use and should be attempted only by an experienced plastic surgeon

BIBLIOGRAPHY

Flap planning in reverse

GILLIES, H D (1932) The design of direct pedicle flaps *Brit med J* 2, 1008

Vascular adjustments in flaps

DOUGLAS, B & BUCHHOLZ, R R (1943) The blood circulation in pedicle flaps *Ann Surg* 117, 692

GERMAN, W , FINESILVER, E M & DAVIS, J S (1933) Establishment of circulation in tubed skin flaps *Arch Surg (Chicago)*, 26, 27

Tests for adequacy of circulation in flaps

BARRON, J N (1955) The congestion test *Brit J plast Surg* 8, 114

BARRON, J N , LAING, J E , COLBERT, J G & VEALL, N (1952) Observations on the circulation of tubed skin pedicles using the local clearance of radioactive sodium *Brit J plast Surg* 5, 171

HYNES, W (1948) A simple method of estimating blood flow with special reference to the circulation in pedicled skin flaps and tubes *Brit J plast Surg* 1, 159

PART TWO

THE SURGICAL APPLICATIONS

CHAPTER FIVE

General Surgery

THE need for plastic surgical methods in general surgery arises in many different ways and the only factor common to all is that skin requires to be replaced Skin loss may have resulted from the pathological process itself from the surgical attack on it or from a combination of both Consideration of the various ways in which the need for repair arises will be concerned particularly with the influence of the pathological condition on the surgeon s approach and how it dictates the type of repair necessary

A few miscellaneous conditions defy classification but most examples of skin injury or loss requiring replacement fall into the broad categories of **traumatic, infective** and **post-surgical**

TRAUMATIC SKIN LOSS

Trauma can be **thermal, mechanical** and **radiational** It is not proposed to discuss thermal trauma as a separate entity for an adequate discussion would entail consideration of aspects outwith the scope of this book but much of the discussion on the granulating area and its skin cover is directly applicable to the care of a full thickness skin loss burn

Mechanical Trauma

Mechanical injury may denude any skin area but the parts particularly prone to injury of this type are the *scalp* the *limbs* and the *scrotum*

The scalp

The usual mechanism less common with shorter hair styles and a more widespread use of suitable hair-enclosing caps in industry is for the hair to be caught in machinery avulsing part

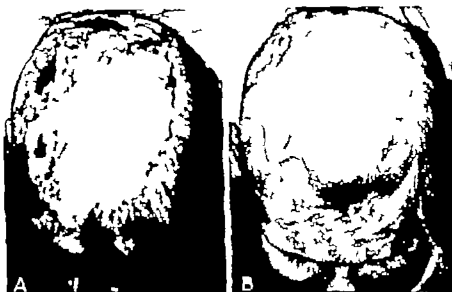


Fig 5 1

Immediate cover with split-skin grafts following scalp avulsion when the pericranium is intact showing the rapidity of healing

A Appearance two weeks after injury
B Seven weeks after injury showing complete healing



Fig 5 2

Use of a dermatome split-skin graft in secondary replacement of forehead skin when the cosmetic result of the primary graft is unsatisfactory

A The poor cosmetic result of pinch grafts applied primarily
B Replacement with the dermatome graft

or all of the scalp It is an injury of females The avulsed segment may be partially or completely avulsed

If only *partly avulsed* the flap should be preserved no matter how small its pedicle and should be sutured back in position after suitable toilet, shaving, etc The blood supply of the scalp is so good that much more of the flap may survive than the size of the pedicle might suggest Once dressed, the area should be left untouched for a week by which time a good demarcation line will have developed between viable flap and slough The slough can now be excised without delay while it is still dry and relatively sterile To await natural separation is a mistake If there is no contra-indication excision can be followed by the application of an immediate split-skin graft Failing that, closely set sheets of skin can be applied 4 or 5 days later The main contra-indication to the immediate graft is the inclusion of the pericranium in the avulsed flap, the treatment of this complication is described below

When the segment has been *completely avulsed* it should under no circumstances be sutured back in position There is no prospect of such a free graft taking and the optimism of the surgeon watching and hoping will only delay the removal of the inevitable slough

Treatment depends on the plane of avulsion The usual plane of cleavage is through the loose areolar tissue deep to the galea aponeurotica and the pericranium which this leaves intact makes an excellent bed for a graft It should be completely covered with split-skin sheet grafts as a primary measure (Fig 5, 1) Probably the crucial point of technique is to avoid too much pressure in applying the dressing There is no "give" in the skull and too much pressure will cause ischaemic necrosis of the pericranium and give rise to a slough which when removed leaves the underlying bone bare When the forehead is involved, the smooth, uniformly thick graft of the dermatome gives the best cosmetic result It can be applied either as a primary procedure or secondarily after excising the primary graft (Fig 5, 2)

More rarely the skull is either partly or completely denuded of pericranium over the area of avulsion and treatment of the bare area of skull becomes quite different, more tedious and difficult Bare outer table of skull will not take a graft and methods have to be adopted to produce "bleeding bone" which will granulate (Fig 5, 3) The fastest and surest way of getting the bone to

The usual cause is either the catching of a limb in power driven rollers e g the wringer of a washing machine or the running over of a limb by a pneumatic tyre both of which produce a sudden severe shearing strain (Fig 5, 4) The results differ only in severity Bony or joint injury may be associated but the characteristic feature is the flaying of the skin The word

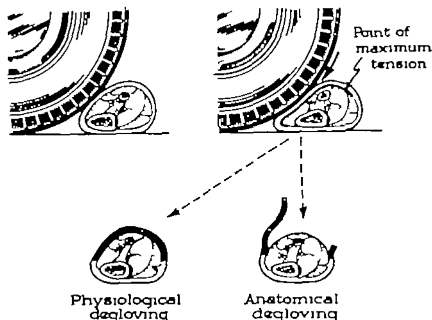


Fig 5, 4

The mechanism of degloving (after Slack)

flaying must be qualified for it may be *anatomical* or *physiological* If anatomically flayed the skin is actually torn off if physiologically the skin surface is intact but there is complete disruption at the level of the deep fascia with undermining At the same time the vascular network of the skin is damaged more or less severely by the sudden extreme tension set up by the shearing strain usually severely enough to cause ischaemic necrosis of skin and superficial fascia

It must be realised that initially there may be little evidence clinically of the severity or extent of the vascular and skin damage—unless it is tested for The clinical sign to be looked for in such an injury is failure of the skin to blanch when pressed with return of colour when the pressure is released or when a skin edge is present absence of dermal bleeding Both signs indicate absence

granulate is to chisel away the outer table of skull With experience an immediate split-skin graft can be got to take on such a surface but little is lost by waiting until reasonable granulations have developed Chiselling has frequently to be repeated as small areas fail to granulate The whole procedure is extremely tedious for both patient and surgeon The end result, too, is much less satisfactory as the lack of mobility and cushioning under the graft make it susceptible to minor trauma



FIG 5, 3

Healing following destruction of the pericranium In this example destruction was by burning but the sequence of events is similar when the skull is exposed by avulsion of the scalp

A Bare outer table of skull
B Patchy granulations four months later
C State of healing thirteen months after A showing areas of instability

No hair grows from the avulsed area and this may call for subsequent surgery The position can sometimes be improved by moving a flap of any remaining normal scalp to the front of the scalp to provide an anterior hair-line The hair growing back from such a flap brushed appropriately can cover the bald area and though never quite natural gives a better result than most wigs

Attempts have been made to apply grafts cut from the avulsed scalp in an attempt to get hair to grow but to date the results have largely been negative

The limbs

Extensive loss of skin from a limb is most often the result of a wringer or roller injury which causes degloving Although this is becoming a much more common injury it is clear, judging from patients referred at a later stage to plastic surgery units, that the condition is less well known than it deserves to be

debridement if necessary As much skin as possible should be applied with priority to the flexures and areas with underlying tendons

Damage to muscle is often present and excision of necrotic tissue must be as radical as is consistent with the preservation of such vital structures as arteries and nerves Only on a healthy base will a graft take and residual necrotic tissue will mean graft failure.

Associated bony or joint damage will complicate matters but an open joint may be closed and a graft applied with good hope of take The exposure of tibia or ulna which are the bones most liable to be bared may add to the difficulties but in such a situation a universal solution is not practicable and consultation between orthopaedic and plastic surgeon is desirable

The avulsed skin is often relatively undamaged and in those circumstances it may be possible after all the subcutaneous fat has been carefully excised to re apply the skin as a whole skin graft This measure cannot be recommended for routine use It requires experience and judgment to select the appropriate case

Above all things should not be allowed to drift until the slough separates slowly and spontaneously If the injury has not been recognised primarily and only becomes obvious when a slough forms the slough should be excised as soon as demarcated and the area grafted To wait beyond this is to wait for the infection mess and delay of slough separation with consequent grafting difficulties

The scrotum

The catching up of the scrotal skin with the trousers on a horizontally rotating shaft is the usual cause of avulsion of the scrotum In the past the denuded testicles were implanted in the thighs or covered by a flap but it has been shown that they can be covered with a free skin graft Often the avulsed skin is available and relatively undamaged and it has been successfully used as a whole skin graft after careful excision of the dartos muscle layer As an alternative the use of a split skin graft has been described

These techniques should only be used by an expert success calls for experience and skill Such cases should be referred to a plastic surgery unit in the first instance

of active skin circulation Over the whole undermined area the skin must be regarded as suspect and the surgeon must decide what is viable and can be saved, or dead and to be excised It is positive evidence of circulation which decides viability and if there is not positive evidence of viability the skin should be excised

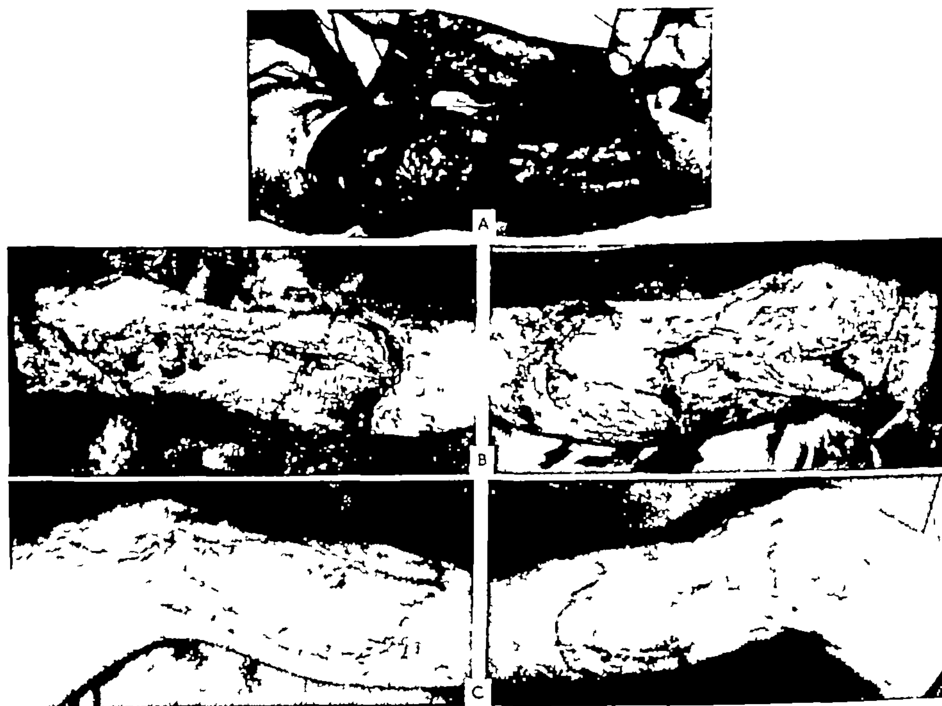


FIG 5, 5

Degloving of leg primarily resurfaced with sheet split-skin grafts
A Extent of injury
B First dressing seven days later
C Healing with full function

A clearer picture of the skin area which retains an active circulation can sometimes be obtained by observing the distribution of the reactive hyperaemia which develops when a sphygmomanometer placed proximal to the injured segment is released after being left inflated for 5 minutes—the **tourniquet test**

Here as in the scalp early grafting should be carried out (Fig 5, 5) Although the general condition may overshadow the local and dictate at least temporary delay a local assessment should be made as soon as possible, the non-viable skin being excised and the resulting defect split-skin grafted after suitable



Fig 5, 6

Examples of radionecrosis and radiodermatitis

A Radiodermatitis of neck following radiotherapy for thyrotoxicosis

B Radionecrosis of chin floor of mouth and mandible with fistula following irradiation of squamous carcinoma of floor of mouth The tube pedicle raised for repair of the ulcer is shown in Fig 4, 6A

C Radionecrosis of chest wall resulting from radiotherapy following radical mastectomy for carcinoma showing central deep ulceration with exposure of ribs and surrounding radiodermatitis

D Radiodermatitis following radiotherapy for acne vulgaris Rodent ulcers of right lower eyelid and right pre auricular region are present and since this record was made multiple rodent ulcers have been removed as they appeared

A further example of radiodermatitis is shown in Fig 4, 7A following radiotherapy for sycosis barbae

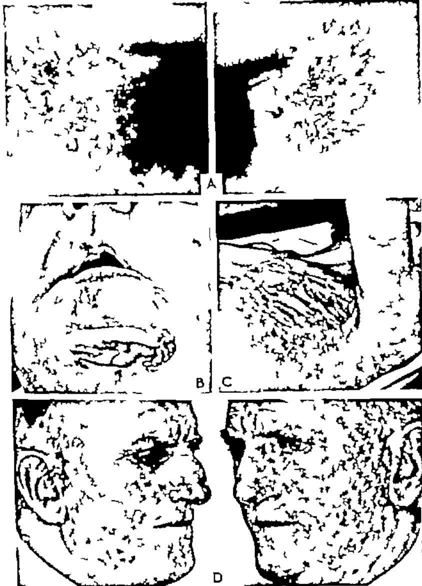


Fig 5 6

Examples of radionecrosis and radiodermatitis

A Radiodermatitis of neck following radiotherapy for thyrotoxicosis

B Radionecrosis of chin floor of mouth and mandible with fistula following irradiation of squamous carcinoma of floor of mouth The tube pedicle raised for repair of the ulcer is shown in Fig 4, 6A

C Radionecrosis of chest wall resulting from radiotherapy following radical mastectomy for carcinoma showing central deep ulceration with exposure of ribs and surrounding radiodermatitis

D Radiodermatitis following radiotherapy for acne vulgaris Rodent ulcers of right lower eyelid and right pre-auricular region are present and since this record was made multiple rodent ulcers have been removed as they appeared

A further example of radiodermatitis is shown in Fig 4 7A following radiotherapy for sycosis barbae

Radiational Trauma

The forms of radiational trauma which may call for plastic surgical methods are **radionecrosis** and **radiodermatitis.** These conditions are late results of irradiation (Fig 5, 6) and many of the worst examples are seen in patients treated inexpertly for conditions in which radiotherapy has either long since been abandoned as a therapeutic measure or in which the actual method of treatment has been radically modified, as for example in thyrotoxicosis, tuberculous cervical adenitis, sycosis barbae, acne vulgaris, lupus vulgaris, haemangioma and many others

With a greater awareness of the dangers of radiation and more expert use of the various techniques these late complications are less common but they still do occur even in the most careful hands The area particularly prone to develop radionecrosis or radiodermatitis sufficiently severely to merit surgical treatment is the oral cavity and its environs when a carcinoma has been treated by radiotherapy The ear and the post-mastectomy scar are also sometimes involved

In both necrosis and dermatitis the constant factor is general avascularity of the affected area and this influences the surgical approach in two ways

1 Unless the area is excised deeply beyond the damaged zone, the resulting granulations tend to be poor and the chances of take of a free skin graft either at the time of excision or subsequently are poor

2 The suture holding properties of therapy-damaged skin are bad and the tissues are slow to heal

Which tissues have borne the brunt of the damage will depend on whether the skin or deeper structures have been the primary target of the radiotherapy and this must be assessed before deciding on the type of repair The mobility of the skin is a good clinical indicator of whether the deeper structures are involved

If skin alone is damaged, excision and replacement with a split-skin graft or whole skin graft is usually satisfactory If, on the other hand, an ulcer is present, it may be assumed that deeper tissues are grossly involved In such a situation, a blood carrying flap will be needed and excision of the ulcer should be as radical as is technically feasible deeply, clearing therapy-damaged skin at the margins If bone is involved a sequestrectomy may be done

easier and of not obscuring the field when recurrence is being watched for

One of the few situations which might call for the primary use of a flap would be one where excision leaves a surface which cannot take a free skin graft for example cortical bone or tendon The advantages of flap cover must then be weighed against the degree of certainty of adequate excision

The pros and cons of immediate flap repair arise with greater urgency in neoplasia of head and neck and will be considered in detail then but much of the argument applies to the problem elsewhere in the body In practice the flap has a very minor role in providing immediate skin cover following excision of a malignant skin tumour

Neoplasia of the Head and Neck

This subject is a vast one and will be discussed only as it affects the surgical procedure As in other fields of surgery pathology should govern practice So many malignant neoplasms of head and neck are local conditions that adequacy of excision becomes of paramount importance and thoughts of subsequent repair must never influence excision if this will in any way contravene pathological considerations The merits and demerits of primary definitive repair following excision thus emerge as a matter of overall policy Considerations of age general condition absolute certainty of excision etc may all influence an individual decision discussion here is concerned with the general problem

The defect left when a malignant lesion has been excised can *usually be repaired either by a free skin graft or a flap* Often the flap would give a much better cosmetic result and solely on those grounds would be preferable The free skin graft on the other hand *with the exception of the post auricular whole skin graft* around eye and nose gives a relatively poor cosmetic result Despite this its merit on pathological grounds is unassailable for its use allows inspection of the operative field for any recurrence and permits early biopsy of any area which is remotely suspicious Recurrence deep to a flap would be disastrously large before its presence would be sufficiently evident clinically to tempt the surgeon to interfere with his flap

simultaneously Unfortunately where sequestrectomy is needed the margins of necrosis are difficult to define and this is especially true of the mandible which is often the bone involved

Before any ulcer is treated a biopsy must be considered to exclude malignancy since this will naturally influence the extent and depth of excision In this connection it is worth remembering that a malignant ulcer developing in therapy-damaged skin is seldom clinically typical and recurrences of skin tumours following radiotherapy are very liable to masquerade as radionecrosis until biopsy reveals the true state of affairs

INFECTIVE SKIN LOSS

With the advent of the antibiotics skin necrosis from fulminating cellulitis is uncommon, but it may still occur from an uncontrolled infection by *Str pyogenes* or as a result of post-operative progressive bacterial synergistic gangrene, which gives rise to the chronic undermining ulceration brought to surgical notice by Meleney

With either infection the problem of skin cover arises once the infection has been controlled and in both instances two conditions must be satisfied—the granulations must *look* healthy with evidence of marginal healing, and the bacterial flora must be innocuous Probably stamp grafts closely placed are the appropriate type of repair, they are certainly the safest

POST-SURGICAL SKIN LOSS

A post-surgical skin defect may arise as a result of excision of a tumour of skin itself or one involving skin secondarily, as in carcinoma of breast Skin grafting has also been used in the treatment of certain anal conditions

Neoplasia of Skin

The head and neck apart, the policy of skin replacement following excision of a malignant tumour of skin is a straightforward one The cosmetic aspect is of minor significance as a factor in deciding type of repair and the split-skin graft applied immediately after excision is the usual method employed The free skin graft has the advantages in this field of being technically

easier and of not obscuring the field when recurrence is being watched for

One of the few situations which might call for the primary use of a flap would be one where excision leaves a surface which cannot take a free skin graft for example cortical bone or tendon The advantages of flap cover must then be weighed against the degree of certainty of adequate excision

The pros and cons of immediate flap repair arise with greater urgency in neoplasia of head and neck and will be considered in detail then but much of the argument applies to the problem elsewhere in the body In practice the flap has a very minor role in providing immediate skin cover following excision of a malignant skin tumour

Neoplasia of the Head and Neck

This subject is a vast one and will be discussed only as it affects the surgical procedure As in other fields of surgery pathology should govern practice So many malignant neoplasms of head and neck are local conditions that adequacy of excision becomes of paramount importance and thoughts of subsequent repair must never influence excision if this will in any way contravene pathological considerations The merits and demerits of primary definitive repair following excision thus emerge as a matter of overall policy Considerations of age general condition, absolute certainty of excision etc may all influence an individual decision discussion here is concerned with the general problem

The defect left when a malignant lesion has been excised can usually be repaired either by a free skin graft or a flap Often the flap would give a much better cosmetic result and solely on those grounds would be preferable The free skin graft on the other hand with the exception of the post auricular whole skin graft around eye and nose gives a relatively poor cosmetic result Despite this its merit on pathological grounds is unassailable for its use allows inspection of the operative field for any recurrence and permits early biopsy of any area which is remotely suspicious Recurrence deep to a flap would be disastrously large before its presence would be sufficiently evident clinically to tempt the surgeon to interfere with his flap

A proper policy then is to repair excisional defects where at all possible with free skin grafts, including where necessary the wearing of prostheses When the area has been watched for 9–18 months according to the local and pathological circumstances until any recurrence is likely to have appeared, a re-assessment can be made and the definitive repair proceeded with

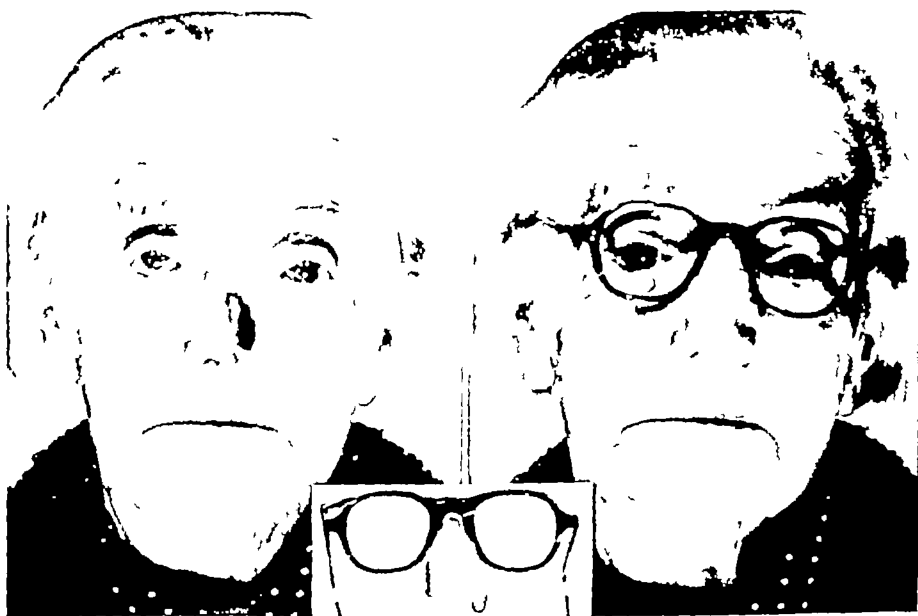


FIG 5, 7

Acrylic prosthesis as permanent "repair" of nasal defect following excision of a rodent ulcer The age and general condition of the patient were considered to preclude definitive repair with the patients's own tissues

Further examples of prosthetic repairs are shown in Figs 4, 29 and 5, 19

if this is felt desirable A permanent prosthesis sometimes gives the best result and if so may be considered as the definitive "repair" (Fig 5, 7)

Circumstances may on occasion necessitate departure from this principle, but they must be overriding before departure becomes justifiable Examples of such circumstances are

1 Where a gross salivary fistula will be produced by the excision This applies especially to older patients who do not tolerate a fistula well, in such circumstances it is wise to aim at primary definitive repair In any case such excisions usually *involve the full thickness of cheek or lip and marginal* recurrence alone need be watched for

2 Where bare skull will be produced by an excision a rotation flap is needed Fortunately deep clearance can be more assured here than in most other situations

3 Where deep clearance is clinically definite but during excision temporo mandibular joint or mandible is exposed Neither is capable of taking a free skin graft and the trismus produced if either is left to granulate before grafting makes a flap necessary

4 Where it proves impossible to achieve complete excision of a tumour it may be worth while to rotate a flap for skin cover so that further radiotherapy can be given

Excluding the free skin graft and there are no special points to distinguish graft usage in the head and neck from elsewhere except the technical problems arising from the need of the patient to breathe and eat the types of repair can best be illustrated by reference to the various parts of the head and neck involved

The lips

The type of repair depends on whether a full thickness defect results from the excision requiring lining to be transferred with the flap employed

Full thickness defects *V excision and direct closure* (Fig 5, 8) Up to one third of either lip can be excised and directly closed without unduly constricting the mouth Suturing as with all lip repairs is in two layers Undermining of the skin for ⅛ inch or so defines the muco-muscular layers which are united with vertical muco-muscular mattress cat gut sutures These sutures take the strain of the repair and allow the skin edges to be closed without tension or tendency to invert

The I lip-switch flap This consists of the transfer of a full thickness flap pedicled on the labial vessels from one lip to fill a correspondingly shaped defect of the other lip (Fig 5, 9) The flap is usually V shaped various eponyms are applied to the several varieties It is a useful repair when the central one third to a half of a lip has been removed and in such a case the lips are attached to each other by the narrow pedicle until it can safely be divided 2 weeks later Where a V has been excised near the angle (Fig 5 10) the switched flap can also be used and the pedicle becomes then the new angle of mouth

A proper policy then is to repair excisional defects where at all possible with free skin grafts, including where necessary the wearing of prostheses When the area has been watched for 9–18 months according to the local and pathological circumstances until any recurrence is likely to have appeared, a reassessment can be made and the definitive repair proceeded with



FIG 5, 7

Acrylic prosthesis as permanent "repair" of nasal defect following excision of a rodent ulcer The age and general condition of the patient were considered to preclude definitive repair with the patients's own tissues

Further examples of prosthetic repairs are shown in Figs 4, 29 and 5, 19

if this is felt desirable A permanent prosthesis sometimes gives the best result and if so may be considered as the definitive "repair" (Fig 5, 7)

Circumstances may on occasion necessitate departure from this principle, but they must be overriding before departure becomes justifiable Examples of such circumstances are

1 Where a gross salivary fistula will be produced by the excision This applies especially to older patients who do not tolerate a fistula well, in such circumstances it is wise to aim at primary definitive repair In any case such excisions usually involve the full thickness of cheek or lip and marginal recurrence alone need be watched for

to fill the defect The secondary defect is closed by taking up the slack present on the cheek It is fortunate that most repairs are

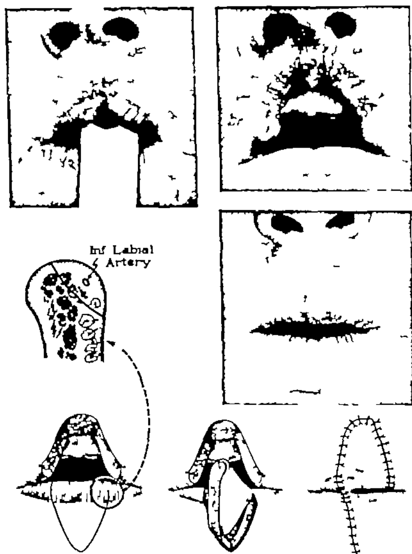


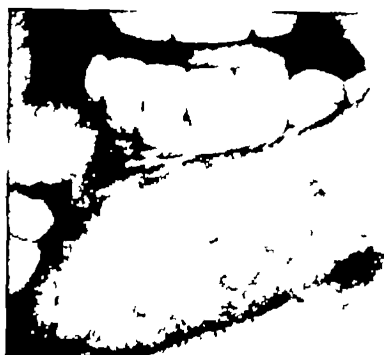
FIG 5, 9

Rodent ulcer of central upper lip closed initially by skin—mucosal suture Definite repair with a V flap pedicled on the inferior labial vessels and switched from lower to upper lip

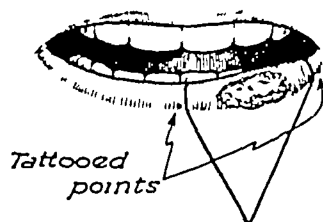
carried out in the older age group where adequate slack in the cheek is usually available

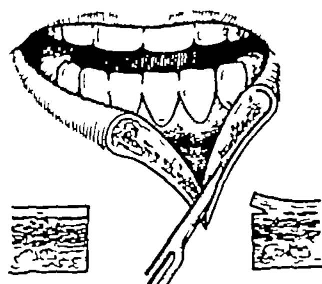
The flap can be rotated until flap red margin meets lip red margin (Fig 5 11) but this reduces the size of the mouth considerably An alternative method which is particularly useful in

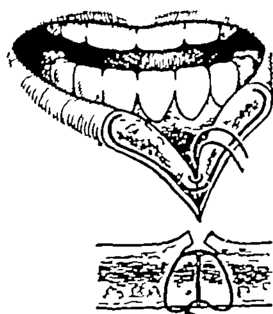
Fan flap When more than half of a lip or a rectangular segment has been excised, the V-lip-switch flap is less effective and a flap











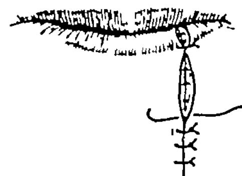


FIG 5, 8

Squamous carcinoma of lower lip treated by V-excision with direct closure showing the two-layer method of suture which is routinely used in repairing the full thickness of the lip

corresponding in shape to the defect must be used Since neoplasms of the lower lip are much more common it is the defect of the lower lip which usually calls for repair

A fan-shaped flap based on the labial vessels of the normal lip and of depth corresponding to the defect is constructed and rotated

must be used to reconstitute the red margin as the alternative method approximating red margins would make the orifice of the mouth impossibly small

Skin and muscle defects. The potential source of material for repair depends on the size of the defect When the defect is of any size the main sources are the forehead and neck For the upper



FIG 5, 11

Excision of two-thirds of lower lip for squamous carcinoma and repair with a single fan flap rotating red margin to meet red margin showing the reduction in the size of the mouth which results The patient refused further surgery to enlarge the aperture of the mouth.

lip and naso-labial region (Fig 5, 14) bridge pedicles of forehead skin based on the temporal vessels are usual Rotation or transposed flaps for the lower lip (Fig 5, 15) are usually taken from the neck either with a secondary free skin graft to the donor site or direct closure if the skin is sufficiently lax

The nose

For small defects particularly where there is no loss of lining the forehead is the usual source of skin To cover the upper nose and adjoining canthal area a flap based on one set of supra orbital vessels can be rotated leaving a forehead defect which can usually be closed by direct suture (Figs 5 16 and 4, 30)

repairs following extensive lip resections is to suture the skin and mucosa of the flap along the line of resection and use it as the red margin (Fig 5, 12) This often leaves a larger mouth

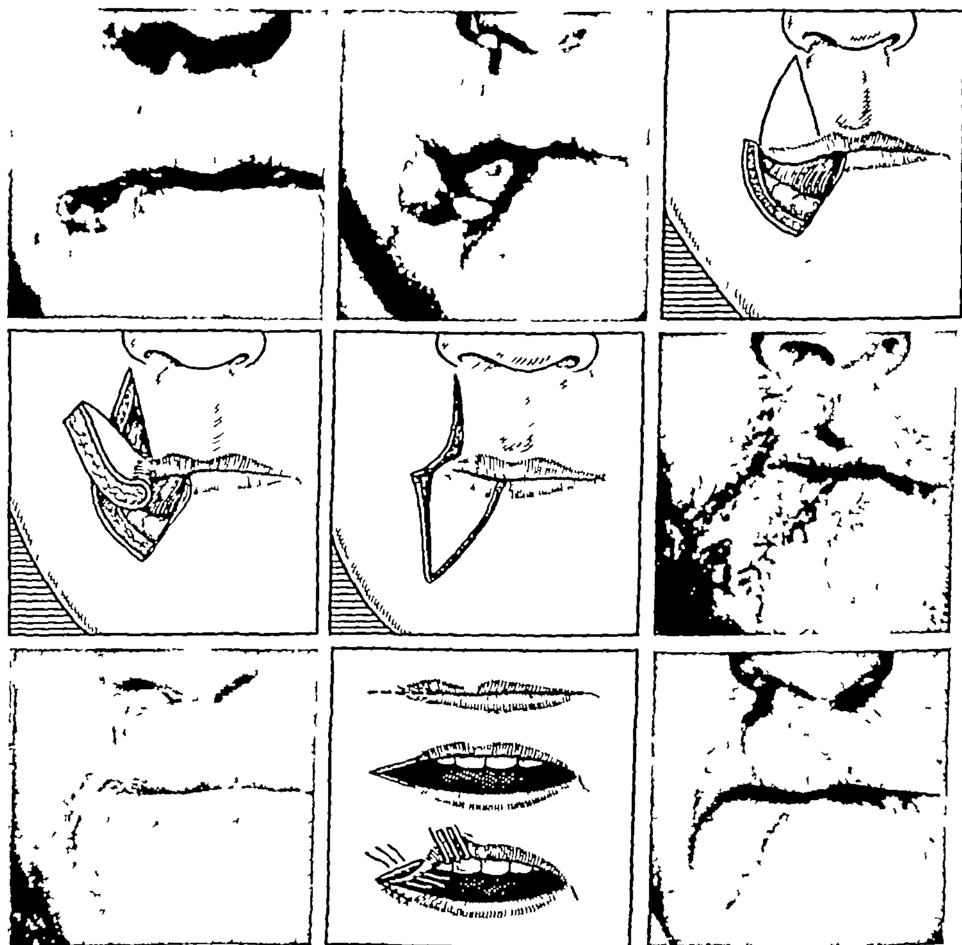


FIG 5, 10

Squamous carcinoma near the angle of the lower lip excised with initial skin-mucosal suture Definitive repair with a V-flap from the upper lip Angle of mouth opened subsequently

In practice the best method is that in which the flap lies most easily

It may happen that the angle of mouth has to be opened up secondarily if the orifice is too small This should if anything be underdone as the opened segment tends to gape in a rather unsightly manner

Bilateral fan flaps can be used to repair a defect of the entire lower lip (Fig 5, 13) In such a situation skin to mucosa suture

must be used to reconstitute the red margin as the alternative method approximating red margins would make the orifice of the mouth impossibly small

Skin and muscle defects The potential source of material for repair depends on the size of the defect When the defect is of any size the main sources are the forehead and neck For the upper



FIG 5 11

Excision of two-thirds of lower lip for squamous carcinoma and repair with a single fan flap rotating red margin to meet red margin showing the reduction in the size of the mouth which results The patient refused further surgery to enlarge the aperture of the mouth

lip and naso-labial region (Fig 5, 14) bridge pedicles of forehead skin based on the temporal vessels are usual Rotation or transposed flaps for the lower lip (Fig 5 15) are usually taken from the neck either with a secondary free skin graft to the donor site or direct closure if the skin is sufficiently lax

The nose

For small defects particularly where there is no loss of lining the forehead is the usual source of skin To cover the upper nose and adjoining canthal area a flap based on one set of supra orbital vessels can be rotated leaving a forehead defect which can usually be closed by direct suture (Figs 5 16 and 4 30)

The reach of this flap is strictly limited and beyond it the usual complication which arises in considering repair if the defect is of

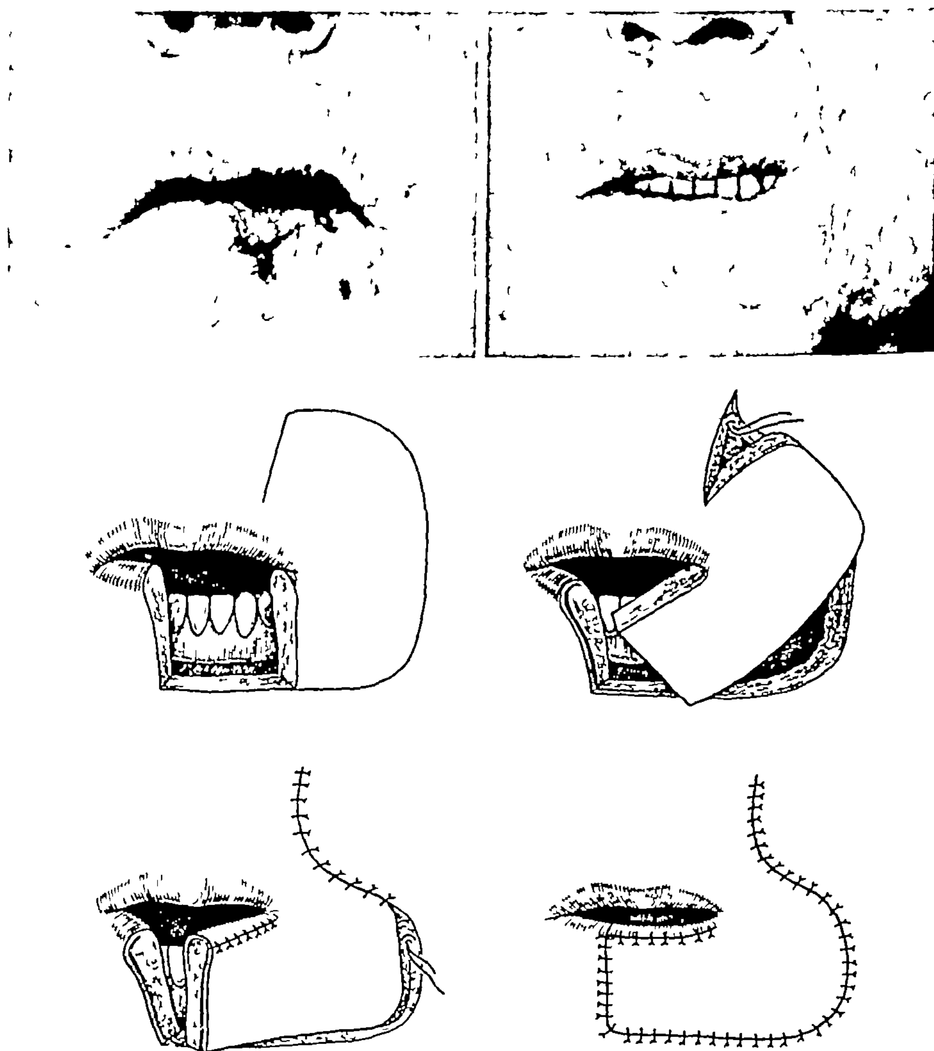


FIG 5, 12

Recurrence of squamous carcinoma of lower lip following radiotherapy excised and repaired by single fan flap with reconstruction of the red margin by advancing mucosa

full-thickness is need of lining The methods of coping with this problem are beyond the scope of this book If no lining is needed, the forehead bridge pedicle flap based either on the temporal (Fig 4, 29) or supra-orbital vessels (Fig 5, 17) is most useful though with a smaller defect a naso-labial flap may be possible

The cheek

The most useful method of repair using local tissues is the inferiorly based rotation flap by which post auricular skin is brought forward (Figs 5, 18 and 4, 23) The defect posteriorly

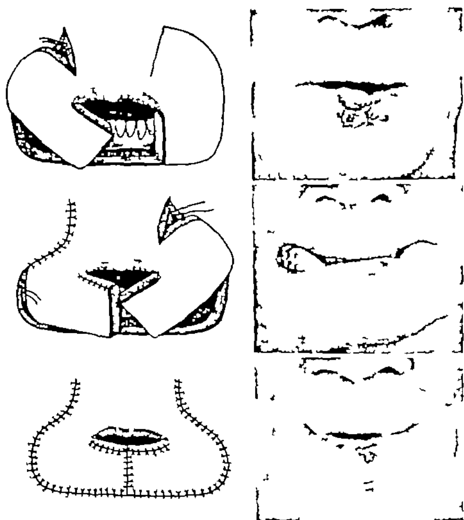


FIG 5, 13

Excision of almost the entire lower lip for squamous carcinoma Initial closure by skin mucosal suture and subsequent repair by bilateral fan flaps

can usually be closed but when a free skin graft *is* needed its relatively inconspicuous position gives a good cosmetic result The method works best where the lesion is long and narrow or is readily triangulated

An alternative method with horizontal lesions of the lower



FIG 5, 14

Rodent ulcer of naso-labial fold (A), excised and repaired primarily with a split-skin graft (B) Definitive repair with temporal bridge pedicle flap (C) after excision of the split-skin graft Immediate result (D) and final result (E) after scar excisions incorporating Z-plasties

cheek is to advance neck skin in association with extensive under mining in the neck The resulting scar tends to stretch very badly and the method cannot be recommended

The ear

Quite unnecessarily complicated reconstructions of ear following limited excision are described and reasonably good results can be obtained by very simple methods (Fig 5, 19) With a tumour confined to the ear two courses are open

1 When the lesion is neither meatal nor peripheral and is

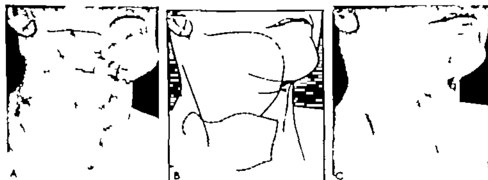


FIG 5 15

Rodent ulcer overlying and invading the body of the mandible excised and repaired by transposed flap

A Extent of excision and delay of flap
B Transfer of flap with development of web across the chin and Z-plasty outlined
C End result after Z-plasty

small enough to be excised leaving enough ear to make recon struction worth while a simple V shaped full thickness excision with the apex towards the meatus and the limbs of the V of equal length should be used giving adequate tumour clearance *Closure of the defect by suturing the limbs of the* V together in the two skin layers produces some distortion but in most cases is entirely adequate cosmetically When good prosthetic facilities are available an alternative method may be to leave the defect fully displayed by suturing the skin on the two sides of the ear together The residual ear can be made the basis of a partial prosthesis (Fig 5, 19B)

2 The peripheral lesion can be dealt with by adequate clearance of the tumour followed by an additional excision of ¼ inch of cartilage to allow the skin to be closed directly over it

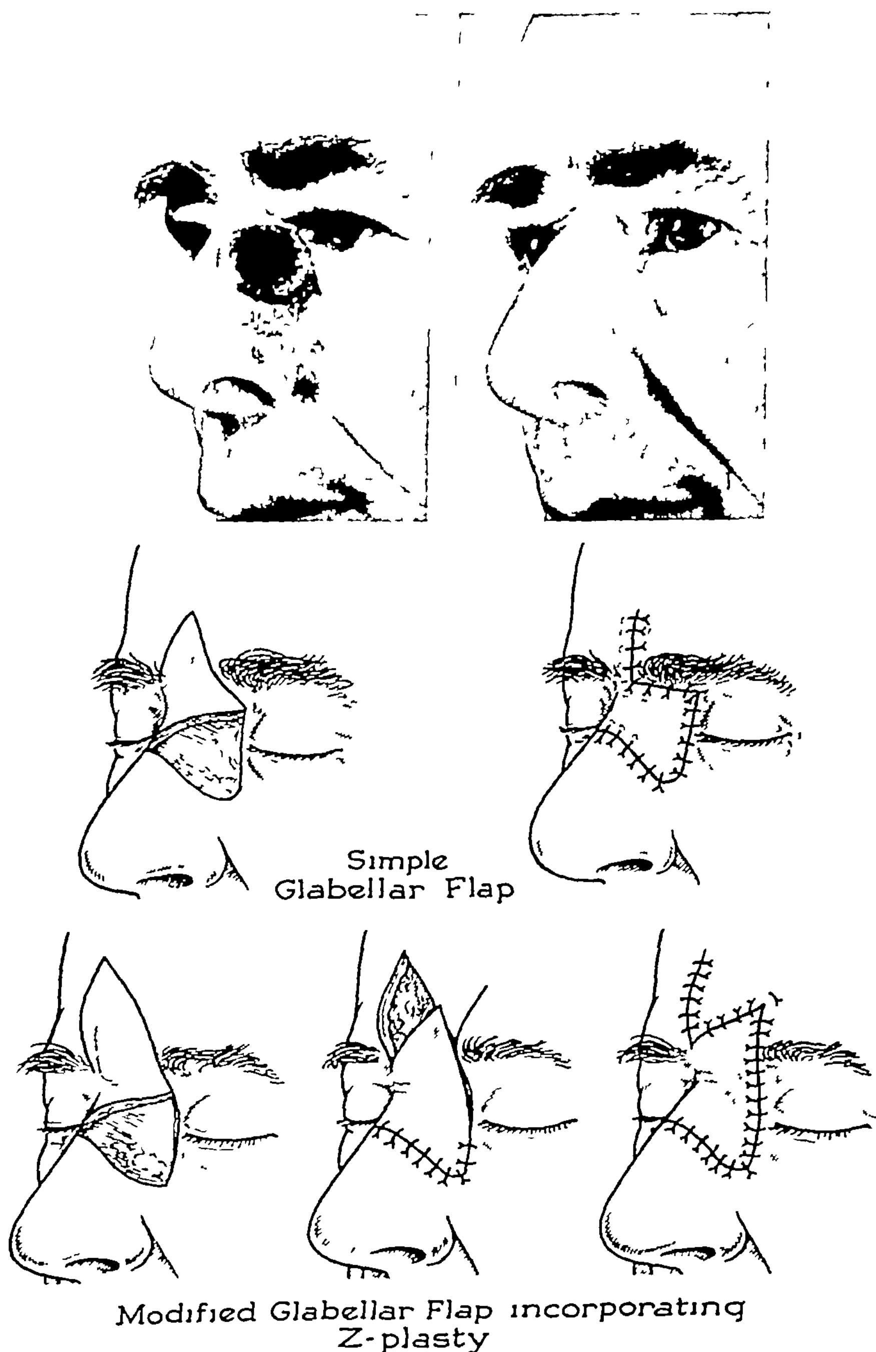


FIG 5, 16

Very extensive molluscum sebaceum (confirmed by biopsy) excised and repaired by simple glabellar flap A modification is also shown which is useful when there is difficulty in closing the secondary defect of forehead

There should be no hesitation however in excising the ear completely and if necessary of removing adjoining skin etc A free skin graft does well in this site making an appropriate

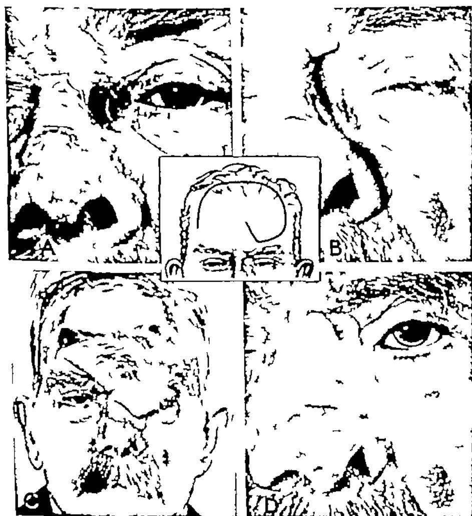
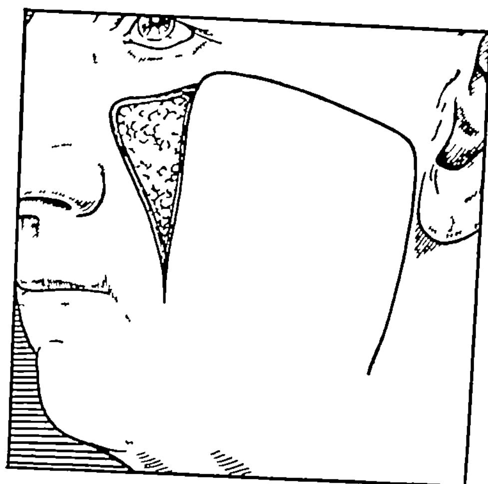


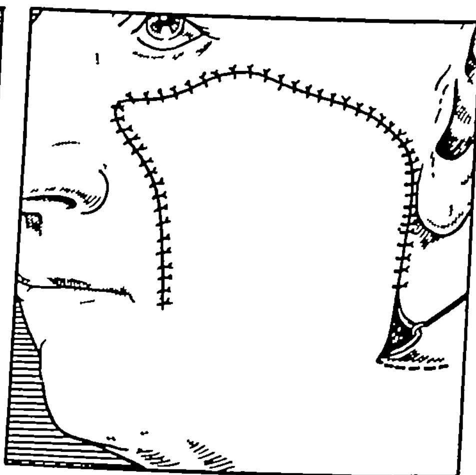
Fig 5 17

Penetrating rodent ulcer of medial canthus and adjoining nose (A) excised and repaired primarily with a split-skin graft (B) After a period of follow-up without recurrence definitive repair by forehead bridge pedicle flap (inset and C) Result following return of bridge segment (D) The patient refused to have further trimming etc of the flap

incision to correspond to the meatal stump (Fig 5 19C) The ear is one of the easiest appendages to replace effectively either with a partial or total prosthesis









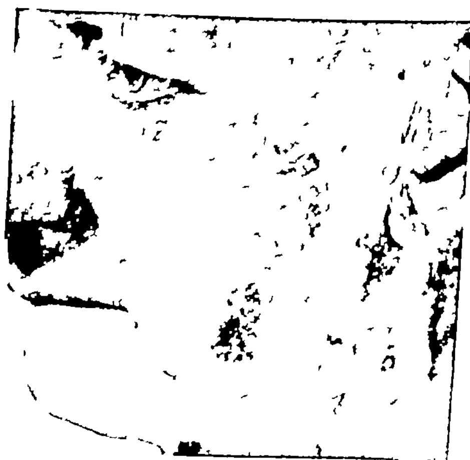


FIG 5, 18

Premalignant keratosis of cheek excised and repaired by modified rotation flap using the method described in Fig 4, 28

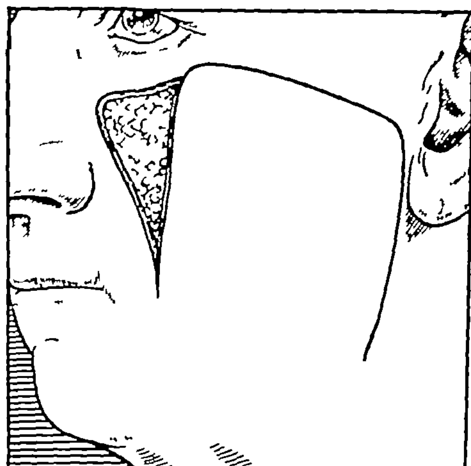


FIG 5, 19

Repairs following excision of neoplasms of ear

A Excision of squamous carcinoma of helix with direct skin closure
B Acrylic prosthetic replacement following partial excision of helix for squamous carcinoma
C Extensive rodent ulcer of pre-auricular skin involving the pinna by direct spread radically excised and repaired by split-skin graft and acrylic prosthesis





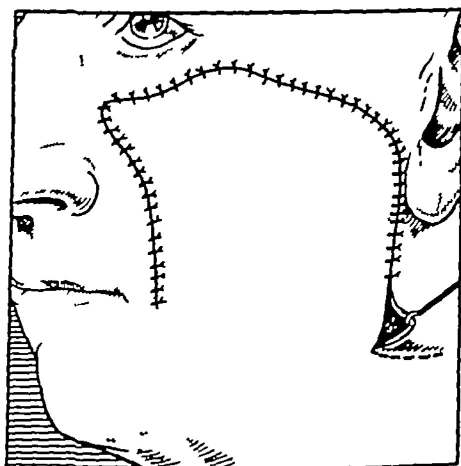






FIG 5, 18

Premalignant keratosis of cheek excised and repaired by modified rotation flap using the method described in Fig 4, 28

grafted immediately but the deeper cavity left after the treatment of an ano-rectal fistula where haemostasis is more difficult is probably better left for secondary grafting When secondary grafting is being used the wound can be packed for the 2 days and then gently cleared of clot to receive the graft With either method massive cat gut ligatures should be avoided

The actual method of applying the graft does not differ from elsewhere a split skin graft overlapping the margin of the raw surface is used with the usual tie over dressing A thin split skin graft is preferable because of its better taking properties The secondary contraction of such a graft is of no moment and such contraction as does occur can be turned to advantage in reducing the depth of the grafted cavity

After the first dressing on the fourth to fifth day all dressings are discarded and the bowel can safely be opened if the area is gently and carefully cleaned afterwards The use of a skin graft need not influence the administration of intestinal antibiotics as a cover during surgery of the anal condition

It is a fortunate coincidence that the surgical steps essential for good graft take should be those necessary to eliminate the particular pathological condition for it means that partial or even complete failure of the graft to take is not an irreparable disaster local treatment can if necessary proceed as though a graft had never been used

MISCELLANEOUS CONDITIONS

Varicose and gravitational ulceration

The part played by plastic surgical methods is only a very minor facet of the treatment of this condition The provision of skin cover does not influence the fundamental circulatory deficiency and unless this is coincidentally treated grafting is a complete waste of time ulceration will inevitably recur Only the methods of providing skin cover will be considered here

Grafting the ulcer Using the methods already described the granulations must be prepared for grafting Of these measures pressure is probably the most important Marginal healing and an absence of *Str pyogenes* indicate the time to graft and the best

Carcinoma of Breast

Radical mastectomy involves removal of a large area of skin and further skin loss may be caused by suturing the wound under tension This has led to an increasing awareness of the value of the free skin graft following mastectomy The usual graft used is a thick split-skin graft and the essential point of technique is to ensure close and immobile contact of graft and chest wall The skin flaps are liable to be mobile and it is unwise to rely on them alone for anchorage Various methods are described to give added fixation but as simple as any is to make the graft overlap the defect so that it extends on to the flaps The usual anchoring suture with a bite through intercostal muscle or rib periosteum will fix both graft and flap to the chest wall

By leaving the sutures long as usual a tie-over bolus dressing can be used to give the necessary local immobility The flaps can be independently drained or treated by continuous suction as preferred, the graft still remains a separate entity fixed to the chest wall

Anal Surgery

In the treatment of fistula-in-ano, anal fissure and anal stenosis it is usual practice to leave at the end of the surgical procedure a widely open, saucerised or flat, raw area to epithelialise slowly from its margins By grafting this area considerable reduction in healing time can be achieved Indeed the methods used to cure the pathological condition and prevent its recurrence, namely the eradication of fistulous tracks, the prevention of pocketing by wide skin excision, and the conversion of the wound into a single, widely open cavity, are the very points one would stress in laying down principles of successful grafting under such conditions

The natural resistance of the perineum to its normal flora would appear to extend to skin grafts and infection is seldom a problem given good contact between graft and recipient site and no dead space full of haematoma or tissue fluid to provide a culture medium As haematoma is the most likely cause of graft loss, adequacy of haemostasis becomes the deciding factor in whether the graft can safely be applied immediately on concluding the anal surgery or whether it is better applied as a secondary procedure 2 days later The superficial, flat surface can readily be

bearing sites may be involved. When excision is considered desirable two methods of repair are possible

Whole skin graft In most cases this is the easiest and best method (Fig 5, 20) and should be used unless previous treatment e g radiotherapy has caused so much scarring that a bed sufficiently vascular to accept a graft is unlikely Skin from thigh



Fig 5, 20

Plantar wart (A) excised and repaired by full thickness graft (A_1) Recurrence (B) at the margin of a graft applied at the time of previous excision of a plantar wart

or abdomen has an adequate thickness of dermis to provide a good pad.

Local flap Gross scarring is the main indication for using a flap and such a flap must come from a non weightbearing area The source (Fig 5 21) is usually the side of the foot when the wart is near the margin or the plantar surface distal to the weight bearing ridge of metatarsal heads when the wart is on that site The secondary defect has to be grafted which explains why the flap must be taken from a non weightbearing area

With both methods the common cause of failure is marginal recurrence (Fig 5, 20B) Along the margin of the graft or flap though not encroaching on the actual tissue transferred the typical callosity gradually develops with return of symptoms Inadequate removal is not the cause of recurrence for even the most radical of excisions may be followed by the gradual development and spread of the recurrent callosity The infective aetiology of the lesion

graft is a thin sheet split-skin graft Once healed, measures to combat the circulatory defect must continue Grafting may also be used merely as a preliminary to excision and grafting of the whole ulcer-bearing area

Excision of the ulcer-bearing area This is a much more ambitious project and failure is correspondingly more serious The ulcer with its surrounding pigmentation and induration is excised *en bloc* to the level of deep fascia The fascial plane of cleavage in the zone of the ulcer is usually poor or virtually absent and in the vicinity of the medial malleolus this can make dissection extremely tedious and difficult as exposure of a tendon is something of a disaster for over it the graft will fail A thick split-skin graft is usually applied with a tie-over dressing which must be most carefully applied over the instep, for graft failure here leaves bare tendon and the creeping of granulations over sloughing tendon is a depressingly slow process Attempts to hasten matters by excising the slough only produce fresh slough of the tendon left Post-operative immobilisation of the ankle is essential, either by bulk of dressing or more effectively by plaster of Paris

Such an excision can be carried out while the ulcer remains unhealed but the clinical appearance and flora must be satisfactory and it is safer to get the area healed with a split-skin graft before excising and grafting The success of radical excision and grafting in giving permanent cure is probably due largely to the destruction of the perforating vein "blow-outs" which is inevitably part of the procedure

Plantar warts

Fortunately the majority of plantar warts do not require excision and repair and such surgery is usually regarded as a last resort It may be required either because the wart has failed to respond to other methods or because of complications arising from the methods themselves, in particular from over-enthusiastic radiotherapy The warts treated by excision and repair are thus a highly selected group and a particularly unpromising one It is scarcely surprising therefore that surgery cures only a percentage and it should not be lightly undertaken since a cure cannot be guaranteed

The warts which give rise to symptoms commonly overlie the metatarsal heads, particularly the second, but any of the weight-

radical measures the entire area of skin involvement with the associated fibrosed subcutaneous fat and indurated lymphatics must be excised The condition should preferably be as quiescent



FIG 5, 22

Chronic axillary hidradenitis treated by excision of the involved skin areas and replacement by split-skin grafts

as possible before surgery is begun A thick split skin graft with a tie-over dressing is used to cover the defect and an immobilising plaster of Paris shoulder spica may be added to give the necessary stability to the dressing

may explain the tendency to recurrence, certainly much remains unknown about the natural pathology, etc, of the lesion

If there is no recurrence, symptoms are usually completely relieved and even despite marginal recurrence the symptoms are often improved Measures to avoid weightbearing on the area of recurrence may suffice to give virtually complete relief



FIG 5, 21

Examples of transposed flap repairs, after excision of plantar warts

Hidradenitis

This entity is more common than is usually recognised It is an infection of the apocrine sweat glands and may affect any of the sites of these structures The most common site is the axilla (Fig 5, 22) and here it presents as multiple, apparently superficial, furuncles spreading over the axillary concavity It is relatively chronic and, despite opening of the abscesses as they develop, sinuses form which flare up sporadically In severe cases the draining lymphatics become involved in the inflammation and fibrosis

When, in spite of conservative treatment, the condition has persisted long enough and is sufficiently disabling to demand

CHAPTER SIX

Orthopaedic Surgery

SKIN cover in orthopaedic surgery is required because of the need for a sterile field during and after surgery of bone and joint. In acute bony trauma with skin deficiency skin cover can for practical purposes convert an open into a closed fracture with a corresponding drop in the probability of infection. In the late treatment of trauma adequate skin cover permits an operative approach without fear of wound breakdown and infection. When secondary surgery of nerve or tendon is required good skin cover is equally necessary for similar reasons.

The care of the paraplegic has become a matter for the orthopaedic surgeon and the surgery of decubitus ulceration will be considered in this context. The problem of pressure sores extends to the non paraplegic but the principles of surgical treatment apply to both types of ulcer and they will be discussed together.

SKIN COVER IN BONY TRAUMA

When skin loss is associated with bony damage the type of skin cover possible depends on whether a fracture is compound to the skin defect. The fractures most likely to be compound and associated with skin loss are those of the subcutaneous long bones particularly tibia and ulna. The circumstances are often such that much damage to surrounding tissues occurs and there may be degloving anatomical or physiological of greater or lesser extent. These factors affecting as they do the blood supply of the skin which is locally available for skin cover must be kept in mind in planning closure of the wound.

If the loss of skin is small primary suture may be attempted but with larger deficiencies tension of the suture line is likely and may lead to breakdown and infection of the wound. A relaxing incision placed in the long axis of the limb and at some distance

BIBLIOGRAPHY

Traumatic skin loss

BALAKRISHNAN, C (1956) Scrotal avulsion a new technique of reconstruction by split-skin graft *Brit J plast Surg* 9, 38

BROWN, J B & FRYER, M P (1957) Peno-scrotal skin losses, repaired by implantation and free skin grafting *Ann Surg* 145, 656

GIBSON, T (1954) Traumatic avulsion of the skin of the scrotum and penis use of the avulsed skin as a free skin graft *Brit J plast Surg* 6, 283

INNIS, C O (1957) Treatment of skin avulsion injuries of the extremities *Brit J plast Surg* 10, 122

ROBINSON, F (1952) Complete avulsion of the scalp *Brit J plast Surg* 5, 37

SLACK, C C (1952) Friction injuries following road accidents *Brit med J* ii, 262

WATSON, J (1956) Loss of the skin of the scrotum treatment by free skin grafts *Brit J plast Surg* 8, 333

Radiational trauma

BROWN, J B , MCDOWELL, F & FRYER, M P (1949) Surgical treatment of radiation burns *Surg Gynec Obstet* 88, 609

ROUTLEDGE, R T (1954) The surgical problem of local post-irradiation effects *Brit J plast Surg* 7, 134

Anal surgery

HUGHES, E S R (1957) Treatment of ischiorectal anal fistula. *Aust N Z J Surg* 26, 281

Plantar warts

MONROE, C W (1956) The treatment of plantar warts *Plast reconstr. Surg* 17, 168

Chronic hidradenitis

CONWAY, H , STARK, R B , CLIMO, S , WEETER, J C & GARCIA, F A (1952) The surgical treatment of chronic hidradenitis suppurativa *Surg Gynec Obstet* 95, 455

area especially if the bone is normally subcutaneous and for that reason alone such scarring may require replacement with a direct flap or tube pedicle

TENDON AND NERVE INJURY

When a nerve or tendon is injured in association with extensive loss of skin it is necessary to provide a covering of subcutaneous tissue as well as skin to form a satisfactory bed prior to any operation of the nerve or tendon itself and a flap must be used as cover The flap may be transferred as a primary procedure in favourable conditions alternatively it may be used secondarily once primary healing has been achieved by a split skin graft

In the upper limb a direct abdominal flap is usual while in the lower limb a cross-leg flap may be used for a localised skin loss The large defect of lower leg or thigh most often requires an abdominal tube pedicle

OSTEOMYELITIS

It is the unstable scarring of the overlying skin produced by chronic osteomyelitis especially of tibia which usually requires treatment Such an area of scarring is seldom suitable for free skin grafting as it may be necessary to treat the bone either at the time of skin replacement or subsequently and an abdominal tube pedicle or direct flap is used when scarring is extensive The infection must be quiescent before the transfer is begun the best results tend to be achieved when the bony infection is burned out and all that remains is the scarred unstable skin

Operations on the diseased bone can be undertaken during flap transfers only if the treated bone is to be covered immediately and completely by the flap

PRESSURE SORES

Pressure sores occur in bedridden and in paraplegic patients In both the pathological processes are essentially similar and the cause is pressure sufficiently severe and sustained to produce ischaemic necrosis of the skin The ulcers develop in areas where pressure is borne and where the pad of subcutaneous tissue is scanty

from the wound may allow the resulting bipedicled flap to move across the limb sufficiently to close the wound, the resulting secondary defect is covered with split-skin However, it must be appreciated that local tissue damage and degloving may have so disrupted the blood vessels of the skin that this manoeuvre may result in a large slough Such a procedure must therefore be carefully assessed, the relaxation incision must be placed at a considerable distance from the wound so that the flap has at least the safety of breadth, and finally, undermining of the skin is to be avoided as far as possible The procedure tends to work only when the defect could almost be closed by direct suture and it should be used rarely

The rotation or transposed flap is not recommended in acute injury of the limbs Even under optimal conditions such flaps in the limbs must be planned and delayed most carefully and in fact are seldom used

If the defect is large, the only possible method of primary closure is the direct flap—in the arm from the abdomen, in the leg from the opposite leg The surgeon should realise however that a cross-leg flap used in such circumstances is liable to be extremely difficult technically and is by no means free from potential disaster Preliminary delays are not possible and so the dimensions of the flap must provide as large a margin of safety as possible A one to two ratio of length to breadth is desirable and the skin defect may have to be enlarged by excising adjoining normal skin if need be to accommodate a flap of adequate breadth The fracture must be simultaneously stabilised either by plating or intramedullary nailing whichever is appropriate and such a method can only be used if the fracture is seen soon after injury and adequate debridement is feasible

Flap procedures in acute bony trauma should not be lightly embarked on and the co-operation of orthopaedic and plastic surgeon is desirable, the actual decision as to whether closure is either feasible or desirable is a matter for discussion in the individual case When it *is* found possible to cover an area with a split-skin graft primarily this is preferable, for secondary flap cover, if needed, can then be provided at leisure with greater safety

A late problem of mixed skin and bony damage may result from the fact that a secondary orthopaedic procedure, e g bone grafting, cannot be carried out through a scarred or even free skin grafted

area especially if the bone is normally subcutaneous and for that reason alone such scarring may require replacement with a direct flap or tube pedicle

TENDON AND NERVE INJURY

When a nerve or tendon is injured in association with extensive loss of skin it is necessary to provide a covering of subcutaneous tissue as well as skin to form a satisfactory bed prior to any operation of the nerve or tendon itself and a flap must be used as cover The flap may be transferred as a primary procedure in favourable conditions alternatively it may be used secondarily once primary healing has been achieved by a split skin graft

In the upper limb a direct abdominal flap is usual while in the lower limb a cross-leg flap may be used for a localised skin loss The large defect of lower leg or thigh most often requires an abdominal tube pedicle

OSTEOMYELITIS

It is the unstable scarring of the overlying skin produced by chronic osteomyelitis especially of tibia which usually requires treatment Such an area of scarring is seldom suitable for free skin grafting as it may be necessary to treat the bone either at the time of skin replacement or subsequently and an abdominal tube pedicle or direct flap is used when scarring is extensive The infection must be quiescent before the transfer is begun the best results tend to be achieved when the bony infection is burned out and all that remains is the scarred unstable skin

Operations on the diseased bone can be undertaken during flap transfers only if the treated bone is to be covered immediately and completely by the flap

PRESSURE SORES

Pressure sores occur in bedridden and in paraplegic patients In both the pathological processes are essentially similar and the cause is pressure sufficiently severe and sustained to produce ischaemic necrosis of the skin The ulcers develop in areas where pressure is borne and where the pad of subcutaneous tissue is scanty

The Non-paraplegic Pressure Sore

Usual sites are the sacral area and heel, occasionally the iliac crest The cause of the sore, i e the factor producing the immobility, must always be treated before considering active surgery of the ulcer, the patient must be capable of keeping off the pressure point

Local treatment is aimed at getting the ulcer fit for split-skin grafting When the time comes to apply the graft the problem is usually a technical one of immobilisation and the ingenuity of the surgeon may be taxed to get immobility for the 4 days or so necessary for graft take Where all other methods have failed, success has sometimes been achieved by applying closely set thin split-skin stamps without any dressings and merely protected against being rubbed off, the patient being kept on the surface opposite the sore

If, despite local measures, the ulcer becomes static in size, more heroic measures may be contemplated though the local condition has all too often to be subordinated to the general state of the patient This is particularly true in sores of the heel where, in theory, the alternative to a split-skin graft would be a cross-leg flap, an alternative quite out of the question in the aged patient For the sacral area and ilium the alternative to the split-skin graft is usually a rotation or transposed flap, the practice of which will be discussed in relation to the paraplegic

The Paraplegic Pressure Sore

The areas particularly liable to ulcerate lie over the pressure-bearing bony prominences and in the paraplegic the ulcers tend to have much more of an "iceberg" quality with extensive undermining and osteitis of the underlying bone or even pyoarthrosis in severe cases Treatment consists of coverage of the completely excised ulcer with a movable pad of healthy skin and subcutaneous tissue and simultaneous elimination of any underlying bony prominence which could act as a focal pressure point This latter procedure is essential as such prominences left untouched reproduce the mechanical pressure which caused the original ulcer

During the acute phase of the spinal injury, the common sites are over the sacrum and femoral trochanter, er recovery

prolonged sitting in a wheel chair makes the ischial area the most frequent site Sacral ulcers tend to be large and flat with minimal undermining ulcers of the trochanter and ischium usually have a small opening leading into a large slough lined cavity into the base of which the bony prominence projects

Healing of the anaesthetic tissues of the paraplegic is poor and with the slightest provocation the wound will fail to heal following surgery Tension of flaps must be avoided haemostasis must be even more meticulous than usual cavities and dead space must be positively eliminated—failure in any one means failure as a whole When the state of the ulcer permits a preliminary split skin graft is worth using for although useless as a definitive procedure it enables the subsequent surgery to be done in a clean surgical field If skin loss is minimal excision and direct closure may suffice but in most cases a rotation or transposed flap is needed It is seldom possible to avoid grafting the secondary defect but the graft need not necessarily be applied at the actual time of flap transfer Indeed leaving the secondary defect ungrafted (Fig 6, 2) is a useful way to ensure that a large area is available through which any haematoma can drain instead of collecting under the flap to cause tension infection and necrosis The graft can readily be applied 7–10 days later

When multiple sores are present the planning of the several flaps required must be co-ordinated carefully so that the strictly limited areas of available skin are used to the best advantage

Sacral ulcers

The appropriate type of flap depends on the shape of the ulcer Frequently suitable is the bilateral rotation flap of buttock skin based on the inferior gluteal fold (Fig 6 1) and this double flap is especially useful in the sacral pressure sore in the non paraplegic patient If the shape and extent of the ulcer make this flap unsuitable alternatives are the transposed or rotation flap based on the lumbar region (Fig 6, 3) or as a last resort a tube pedicle This latter procedure has many technical difficulties and should not be lightly undertaken

Trochanteric ulcers

Initially the main cavity of the ulcer is the trochanteric bursa and if this alone is involved permanent closure may be achieved

without interfering with the bone Frequently, however, the trochanter and neck of femur project into the cavity and excision of trochanter and appropriate cortex of the shaft is then required to let the soft tissues collapse and obliterate the cavity In the most severe instances a pyoarthrosis of the hip joint develops and,

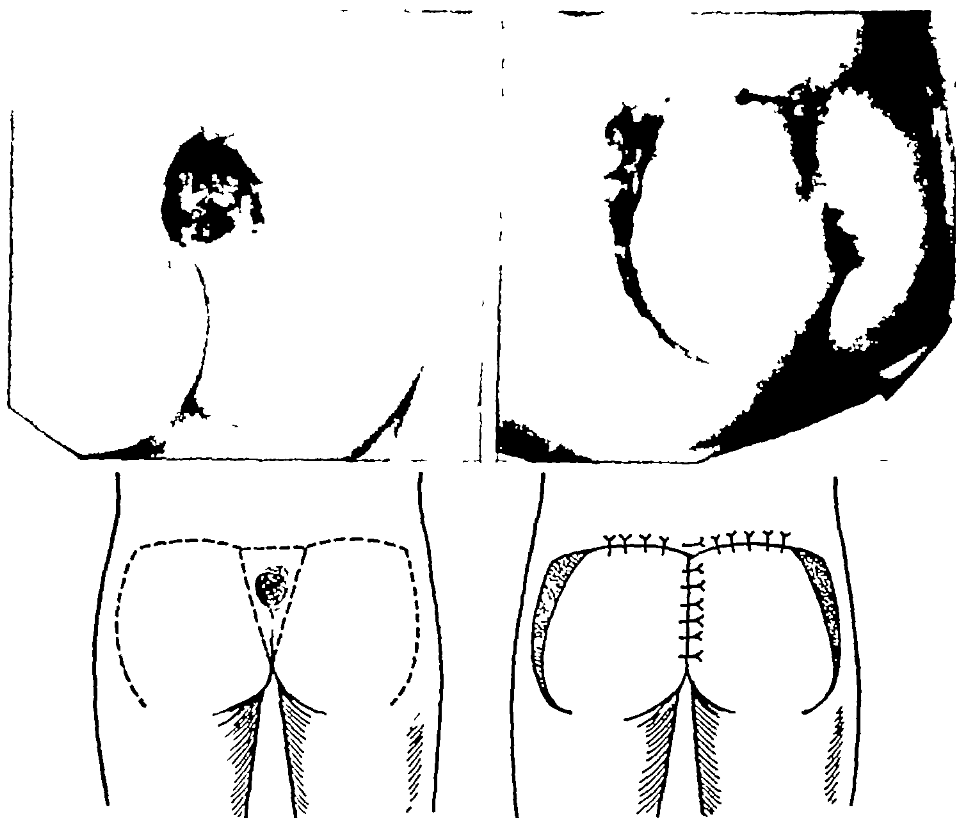


FIG 6, 1

A sacral pressure sore in a non-paraplegic repaired with bilateral rotation—transposed flaps of buttock skin

once present, this complication is virtually impossible to eradicate without amputation It is probably wise in such circumstances to concentrate on improving the patient's general condition as much as possible and accept the permanency of the pyoarthrosis

The ulcer is so undermined in most cases that free skin grafting is seldom practicable, a transposed flap must be used (Fig 6, 2) Its precise situation and shape will depend on the size and shape of the ulcer, with the proviso always that the secondary defect must be on an area free from subsequent weight-bearing

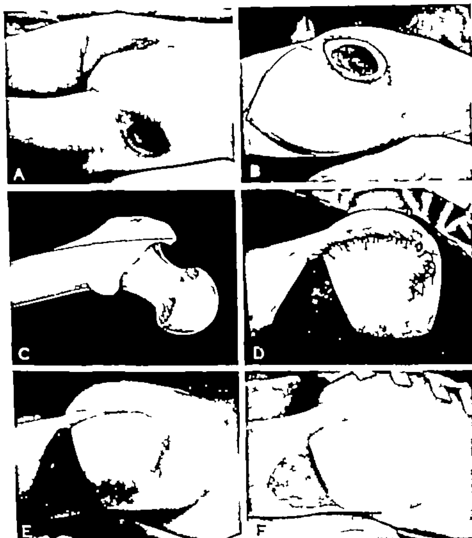


Fig 6 2

A sacral and a trochanteric ulcer in a paraplegic showing repair of the trochanteric ulcer

A The ulcers
B The trochanteric ulcer with the transposed flap outlined
C The wedge of protruding trochanter excised to eliminate the focal point of pressure
D E The flap transferred at operation and 10 days later prior to application of the split-skin graft to the secondary defect
F The end result

It is not necessary always to graft the secondary defect at the time of the flap transfer In this patient the secondary defect was grafted 10 days later

Ischial ulcers

The cavity of the ulcer consists of the ischial bursa, but as the condition progresses and extends the ischial tuberosity projects into the cavity and becomes the seat of chronic osteitis A major advance in the treatment of this type of ulcer has been the excision of the ischial tuberosity jointly with the appropriate soft tissue

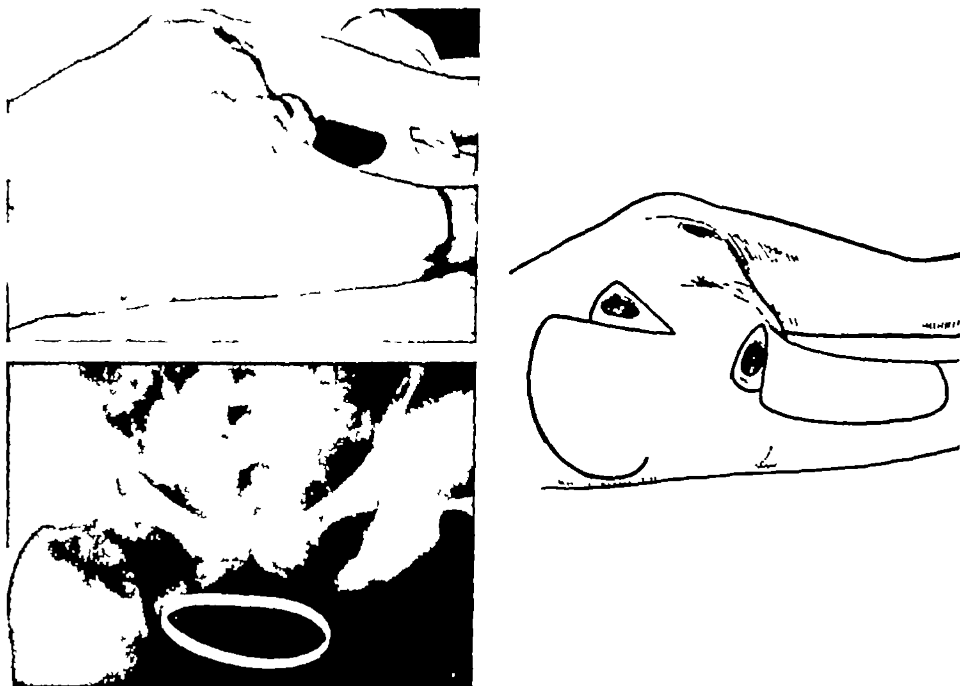


FIG 6, 3

A sacral ulcer and bilateral ischial ulcers in a paraplegic showing repair of the sacral ulcer by a rotation flap of buttock skin and of the left ischial ulcer by a transposed flap of thigh skin The X-ray shows the extent of the ischiectomy on the left side and the osteitis of the right ischial tuberosity

surgery (Fig 6, 3) Even where the bone is not pathologically involved it is still the main cause of the ulceration, certainly its excision has greatly improved the late results

When planning the appropriate flap the patient should have the hip flexed to imitate the sitting posture to ensure that residual scars do not overlie the tuberosity The best flap is very broadly based medially along the greater part of the thigh and moved upwards (Fig 6, 4) Its superiority over other possible designs is due to its generous dimensions which on the one hand make it extremely safe and on the other permit further rotation (Fig 6, 5)

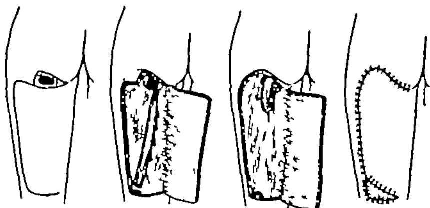


FIG 6, 4

The transposed flap used to repair the defect left following excision of the ischial ulcer and ischiectomy The cavity left by the ischiectomy is filled by detaching at its lower end and mobilising such hamstring musculature as is available

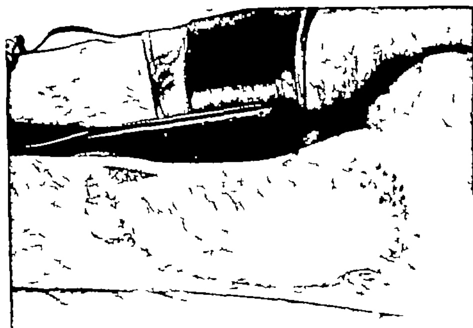


FIG 6 5

Secondary rotation of a previously used thigh flap to repair recurrent ulceration The segment of flap beyond the line of the scar of the previous flap was delayed prior to rotation of the flap

should the ulcer recur An added advantage of this flap is that it enables the atrophic remnant of the biceps muscle to be detached at its lower end and mobilised by dividing approximately half of the perforating vessels The muscle can then be rolled up and tucked into the dead space left by the ischiectomy

It cannot be emphasised too strongly that the procedures which have been described for the various types of decubitus ulceration are only a small facet in the overall care of the paraplegic and must be regarded as merely providing the ulcerated area with a fresh start in the best conditions

BIBLIOGRAPHY

Skin cover in bony trauma

CONNELLY, J R (1956) Plastic surgery in bone problems *Plast reconstr Surg* 17, 129

CUTHBERT, J B (1955) Simultaneous replacement of skin and bone in recent leg injuries *Brit J plast Surg* 7, 343

ESSEX-LOPRESTI, P (1950) The open wound in trauma *Lancet*, i, 745

Skin cover in nerve injuries

LEARMONTH, J R & WALLACE, A B (1943) Certain plastic problems in the surgery of peripheral nerves *Surg Gynec Obstet* 76, 106

Pressure sores

CANNON, B, O'LEARY, J J, O'NEIL, J W & STEINSIECK, R (1950) An approach to the treatment of pressure sores *Ann Surg* 132, 760

CONWAY, H & GRIFFITH, B H (1956) Plastic surgical closure of decubitus ulcers in patients with paraplegia *Amer J Surg* 91, 946

GUTTMANN, L (1955) The problem of treatment of pressure sores in spinal paraplegics *Brit J plast Surg* 8, 196

OSBORNE, R (1955) The treatment of pressure sores in paraplegic patients *Brit J plast Surg* 8, 214

YEOMAN, M P & HARDY, A G (1954) The pathology and treatment of pressure sores in paraplegics *Brit J plast Surg* 7, 179

CHAPTER SEVEN

Hand Surgery

IN surgery of the hand it is essential to avoid the pitfall of seeing the hand in isolation the patient and his condition must be viewed as one Before the surgeon embarks on a time consuming procedure he should give serious thought to whether the end result is going to justify the time spent in obtaining it with the loss of work and income which the patient will suffer He must remember that the very procedure may give rise to disabilities which could outweigh the possible advantages to be derived from it he must decide whether the patient is intelligent enough to benefit from a complicated reconstruction and co-operate fully during its various stages

When the alternative exists a labouring man may well be better off with a partial amputation or free skin graft of his injured finger than a more elaborate repair which will require immobilisation of one or more fingers or even most of the hand wrist elbow and shoulder

The possible complication of shoulder arm and hand stiffness is especially relevant to the older age group and may be a major consideration in deciding the best procedure

When different modes of treatment are equally feasible it is often worth while to explain the problem and its possible solutions in simple terms to the patient so that he may understand what each will entail in time discomfort and end result In this way co-operation during the actual procedure is more likely

HAND INJURIES

In a hand injury the provision of skin cover by direct suture free skin graft or flap takes absolute priority Skin cover alone halts the twin processes of infection and fibrosis which are particularly harmful in the hand The appropriate method of skin

cover depends so much on the type of injury and its extent that an appreciation of the pathological features of the common injury patterns is necessary to an understanding of the principles of treatment

Hand injuries are of three main types—**cutting and slicing, crushing** and **degloving.** As a rule an injury belongs predominantly to one type, but on occasion an injury has the characteristics both of crushing and degloving

Cutting and Slicing Injuries

The extent of a cutting or slicing injury is clear-cut and preliminary clinical assessment of damage is straightforward Tendon and nerve damage are common and must be tested for, but, if one excludes the guillotine amputation which is so often part of the injury, associated bony damage is uncommon With the exception of the partially sliced-off flap, the skin loss is immediately obvious, and even with it the devitalising effect of crushing is not present to add to the difficulty of deciding clinically whether the flap is viable

It is not proposed to discuss the merits of primary tendon repair, discussion will be concerned rather with the means of providing such skin cover as will permit tendon repair or graft, primarily or secondarily

The method of repair can usually be decided on the basis of the preliminary clinical examination When there is no loss of skin direct closure with minimal excision of the wound margins should be carried out, and here accurate suturing is as vital as in the face in order to achieve rapid healing with minimal scarring Skin loss must be made good by free skin graft or flap Free skin grafts, commonly of split-skin thickness, are generally used except when the raw area includes a structure which will not accept a free skin graft, when the pulp of the finger tip has been lost and replacement requires more bulk than is present in a free skin graft, or when subsequent repair of a deep structure such as tendon is contemplated In these circumstances flap cover must be provided and the type of flap depends on the site and size of the defect The possible flaps in the various circumstances will be discussed on page 201

The guillotine amputation which exposes bone is in many cases best closed by trimming the phalanx until the tissues will close directly over it without tension Free skin grafts do poorly over such stumps Failure of the graft over the bone is common and even with good take the scar adherent to the underlying bone tends to make the graft always vulnerable Flap cover may be indicated on occasion but in the majority of patients amputation is to be preferred

These considerations apply with particular force if one finger alone is injured When more than one finger is involved a more conservative approach is indicated and direct flaps from chest abdomen or the opposite forearm must be considered Cross finger flaps are seldom feasible In the thumb a quite different approach is essential and the principle becomes one of extreme conservation Length must be maintained primarily at all costs There should be no excessive trimming of a traumatic amputation to get skin cover a free skin graft or flap should be used as the local circumstances dictate The overriding need for conservation of finger tissue becomes less with passage towards the ulnar side of the hand

Crushing Injuries

A crushing injury may vary in severity and extent from the mildest subungual haematoma through the crush injury of fingers with or without bony damage up to the power press injury which leaves a shapeless pulp of devitalised tissue With severe crushing there is often a bursting laceration The brunt of the injury is taken by the soft tissues and bones rather than the tendons and nerves Loss of skin and soft tissue by the actual injury is not a feature but the real loss is often much greater than is at first apparent for disruption of blood vessels and devitalisation of tissues may give rise to quite extensive skin necrosis This hidden damage may result in unexpectedly severe oedema post operatively and failure to guard against this oedema can further devitalise the crushed tissues particularly if they have been closed under tension

Pre operative appraisal of the situation can be most misleading only during actual cleansing and surgical exploration of the wound

can the injury be accurately assessed The important points in such an assessment are

1 To determine what is definitely not viable The test already described (page 149) to assess the viability of skin must be rigidly applied here and non-viable soft tissue structures excised quite ruthlessly This may mean excision of bone, tendon, etc , when a segment of finger as a whole is judged to be non-viable

2 With the non-viable tissue excised the position is assessed afresh to decide which injured structures are worthy of retention and skin cover The detailed decisions which this implies must take into account such factors as the relative importance of the fingers and the thumb, the age, intelligence, etc , of the patient, and the extent and severity of the damage

Much that has been said of closure following guillotine amputation applies to the crushed finger With the sole exception of the thumb where the conservative approach always applies there are two opposing lines of argument On the one side the more severe the damage to the individual components of a finger—nerve, tendon, skin, bone, the stronger is the argument for amputation though the finger as a whole may be viable, for the less chance there is of a useful digit resulting On the other side the greater the damage to other fingers and the rest of the hand the stronger is the argument for retention of an injured digit even in the knowledge that it may be stiff It is in the crushing injury particularly that a useless finger should always be considered as a potential source of skin Filleted, it can be used to cover a skin defect of adjoining dorsum or palm avoiding the need for graft or flap

It is often stated that any lacerations which are present as part of a crushing injury should only be loosely closed with a few tacking sutures because of the tendency to post-operative oedema In our experience, when no skin has been lost much better results are obtained by suturing such lacerations as accurately as possible with many fine sutures leaving no raw areas between sutures When this has been followed by absolute immobilisation, preferably with plaster of Paris, and scrupulous post-operative elevation for at least 48 hours oedema has not given rise to any trouble It seems likely that the oedema which is so feared is the

result of failure to follow the latter part of the regime described above

Compared with a cutting injury of apparently comparable severity the crushing injury carries a much longer disability period and the results are poorer The problem of the associated fracture will be considered separately

Degloving Injuries

In degloving injuries of the hand as elsewhere the important pathological factor is injury to the vascular system The anatomical characteristics of the palmar skin with its intimate attachment to the palmar fascia make it less liable to degloving but when it is degloved the palmar aponeurosis is usually part of the tissue avulsed. Elsewhere the plane is the usual one between superficial and deep fascia

In the pure degloving injury damage to deeper structures is surprisingly uncommon though it must always be tested for The important surgical decision is that of viability and the tourniquet test may help (see page 150) Retention of skin is only justifiable on the basis of positive clinical demonstration of an active skin circulation Skin which is not demonstrably viable must be excised

The split skin graft is the usual method of cover and should be used unless tendon bone or joint is exposed Even if it is felt that subsequent cover by a flap will be needed the split skin graft is still the primary cover of choice especially when more than one surface of the hand is involved When a direct flap is required primarily it should be designed to cover as much of the raw area as possible with its initial attachment

It is often difficult to estimate the precise skin loss immediately after the injury but over estimation is less serious than under estimation If at the first post operative dressing skin necrosis is found to be more extensive than was expected and fresh slough is present it should be excised and replaced with a split skin graft forthwith In this way healing and mobilisation can be achieved as rapidly as possible

Degloving of a single digit occurs occasionally and again with the sole exception of the thumb amputation is usually advisable The degloved thumb should be inserted into a tubed flap raised on the opposite arm or trunk (Fig 7 1)

can the injury be accurately assessed The important points in such an assessment are

1 To determine what is definitely not viable The test already described (page 149) to assess the viability of skin must be rigidly applied here and non-viable soft tissue structures excised quite ruthlessly This may mean excision of bone, tendon, etc , when a segment of finger as a whole is judged to be non-viable

2 With the non-viable tissue excised the position is assessed afresh to decide which injured structures are worthy of retention and skin cover The detailed decisions which this implies must take into account such factors as the relative importance of the fingers and the thumb, the age, intelligence, etc , of the patient, and the extent and severity of the damage

Much that has been said of closure following guillotine amputation applies to the crushed finger With the sole exception of the thumb where the conservative approach always applies there are two opposing lines of argument On the one side the more severe the damage to the individual components of a finger—nerve, tendon, skin, bone, the stronger is the argument for amputation though the finger as a whole may be viable, for the less chance there is of a useful digit resulting On the other side the greater the damage to other fingers and the rest of the hand the stronger is the argument for retention of an injured digit even in the knowledge that it may be stiff It is in the crushing injury particularly that a useless finger should always be considered as a potential source of skin Filleted, it can be used to cover a skin defect of adjoining dorsum or palm avoiding the need for graft or flap

It is often stated that any lacerations which are present as part of a crushing injury should only be loosely closed with a few tacking sutures because of the tendency to post-operative oedema In our experience, when no skin has been lost much better results are obtained by suturing such lacerations as accurately as possible with many fine sutures leaving no raw areas between sutures When this has been followed by absolute immobilisation, preferably with plaster of Paris, and scrupulous post-operative elevation for at least 48 hours oedema has not given rise to any trouble It seems likely that the oedema which is so feared is the

Finger tip Injuries

Isolated finger tip injuries of all three types are extremely common and the influence on treatment of the nail and pulp makes separate consideration of the injury necessary

The pulp with its skin the phalanx the nail and its bed, each or all may be damaged in varying degree The best treatment by proximal amputation free skin graft or flap depends at least partly on the extent of the damage to each constituent In the extreme case the choice may be clear cut it is in the mixed injury that difficulty arises Severe crushing devitalising the nail and phalanx while the pulp is still viable is best treated by amputating the damaged segment and closing the defect with a flap of pulp skin For the slicing injury which removes either pulp skin or distal nail without significantly damaging pulp or phalanx the obvious measure is a free skin graft The majority of injuries which lie between these extremes with loss of pulp and sometimes of bone are capable of being treated by flap free skin graft or proximal amputation The more bone is exposed the less suitable is the site for a free skin graft for the reasons already given (page 189) The finger tip is one of the very few sites where a whole skin graft has been successfully used in primary trauma but it has no real advantage over a thick split skin graft The flap has its main use where there has been loss of skin and pulp but where bone and nail are undamaged The more bone has been lost the less good will be the result

A finger tip injury which occurs sufficiently often to constitute a distinct injury pattern is the partially avulsed finger tip which is left attached by a pedicle of pulp When the injury is of the crushing type the nail is usually avulsed from its base with the flap the ungual process of the phalanx may be intact but denuded or fractured with the distal fragment as part of the avulsed segment With a cutting type of injury the nail may be cut transversely the distal half remaining attached to the avulsed flap

It is astonishing how small the pedicle need be to ensure survival of the avulsed flap and a decision as to viability should only be made when the flap has been replaced in its correct position to eliminate the adverse effect of torsion and angulation of the pedicle on the blood supply of the flap If it is not viable treatment is as for a guillotine amputation With a viable flap the finger tip

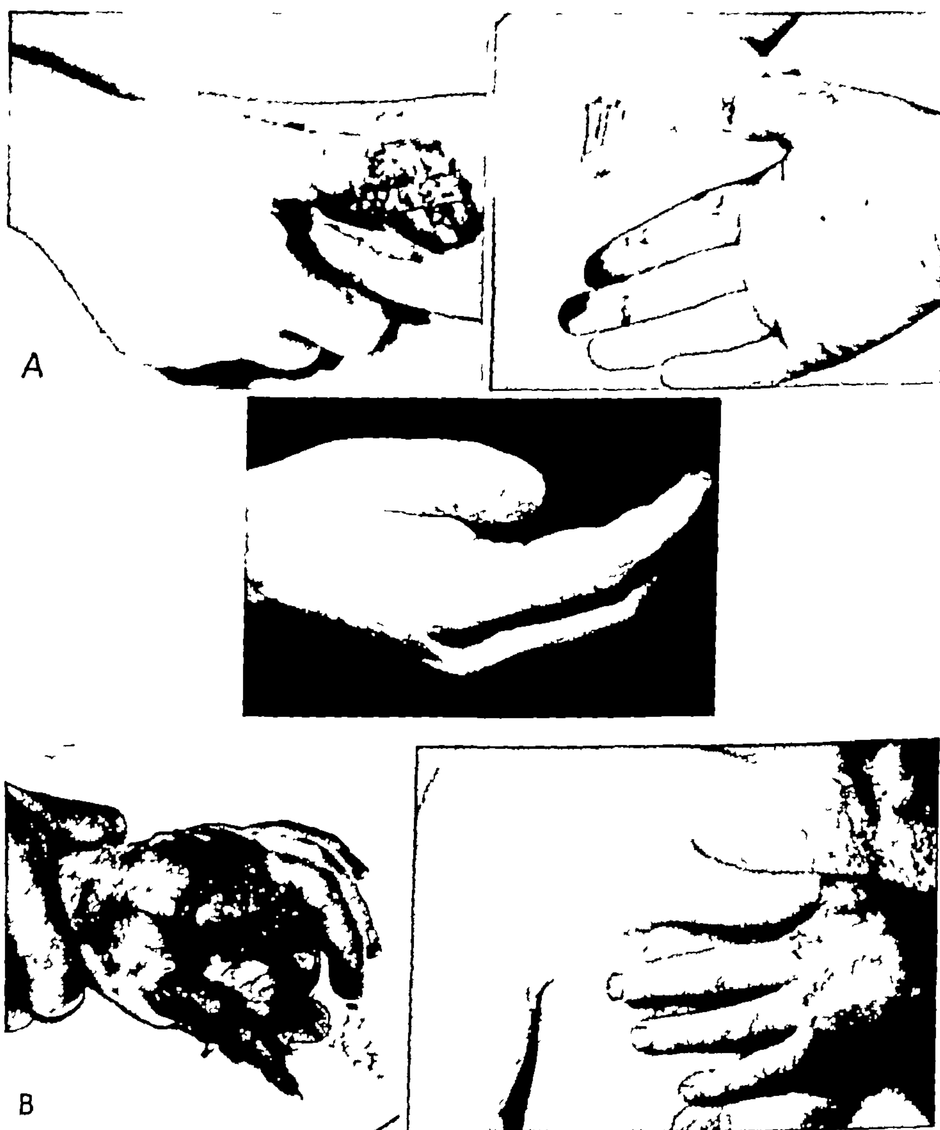


FIG 7, 1

The use of distant flaps in resurfacing the thumb

A Degloving of thumb with loss of distal phalanx, resurfaced with cross-arm tubed flap The use of the graft covering the forearm defect to line the pedicle segment is shown, and the final result

B Use of a pectoral tubed flap to resurface a thumb degloved in a crush-degloving injury which damaged the index finger beyond salvage

While these methods of resurfacing may be the only ways of salvaging the digit, the return of sensation and consequent utilisation by the patient tend to be poor

active exercises within the painless range of movement Movements are progressively increased at the end of the second week and by the end of the third week a full regime of exercises can be instituted

When dressings are still required for the skin component of the injury these should be as light as possible to allow the maximum of unhindered movement In this situation Tubegauz is most useful in providing good cover with a minimum of restraint from sheer bulk of dressing

The method of treatment which has been outlined may be contrary to current orthopaedic text book practice but the great improvement in results since its introduction has justified it

ELECTIVE SURGERY

Plastic surgical principles apply also in elective surgery of the hand both in the surgery of approach to deeper structures and in reconstruction following injury congenital anomaly etc

The placing of scars is important in the surgery of approach but it has a much wider application in relation to grafts and flaps and will be discussed in relation to all three In the late reconstruction of the injured hand the problems of skin cover are similar to those of the acute phase and are usually concerned either with skin replacement following excision of contractures and scar or provision of skin cover to permit reconstruction of deep structures most often tendons The use of free skin grafts and flaps will be considered both for the primary treatment and the late reconstruction

The Z-plasty may be required as a secondary procedure where the principles of scar placement have not been followed at the time of primary repair because of precarious blood supply etc but it is required all too often to correct the contracted scars resulting from wanton disregard of these principles

TECHNIQUES OF REPAIR

Placing scars in the hand

The major palmar and digital creases indicate lines of flexion in various hand positions and incisions directly across them at

should be reconstituted after minimal excision of wound edges and damaged pulp fat The nail should be retained and replaced in its bed to provide splintage and to ensure a smooth nail bed after healing In this way the likelihood of distortion when the fresh nail grows in is reduced When the nail has been transected care should be taken to get the edges accurately apposed for the same reason

The Associated Fracture

A fracture as part of a finger injury adds weight to the argument in favour of amputation, particularly if there is severe comminution Before such a finger is retained skin cover must be demonstrably available and if it is not available the finger should be amputated unless damage to the remainder of the hand makes retention imperative As already emphasised the thumb is an exception to this general rule

If such a finger is retained, the fracture and the soft tissue damage which inevitably accompanies it worsen the prognosis as regards function and add to the problems of treatment If the periosteum on either flexor or extensor surface has been extensively damaged by displaced bony fragments there is corresponding damage to the surface over which the tendons move and adhesions rapidly develop between the two surfaces

Internal fixation by small plate or intramedullary bone peg has been recommended but good results can be achieved by relatively simple methods without recourse to such fixation The criterion of success is function rather than anatomical perfection of bony contour With the skin closed the fracture should be reduced and the finger immobilised in the position of function Plaster of Paris is not always necessary, bulk of dressing often provides entirely adequate splinting

The problem of subsequent care is to reconcile the needs of the fracture and those of the soft tissues Immobilisation for the periods usually recommended for closed fractures means a stiff finger and at the end of that period the mature tendon adhesions added to the scarring of other soft tissues makes subsequent mobilisation virtually impossible A compromise is necessary and it is our experience that by the end of a week to 10 days the fracture is sufficiently "sticky" to permit gentle

lest contraction of the marginal scar recreate the deformity the procedure was designed to relieve

Conversely when the side of the finger is grafted in syndactyly the marginal scar originally antero-lateral tends with flexion of the finger over a period to move anteriorly further away from the neutral line and forms a contracture requiring a Z-plasty It is

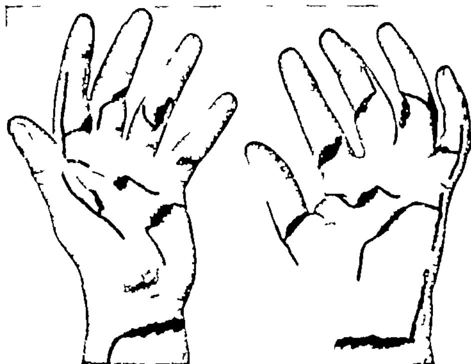


FIG 7 3

Suitable incisions extending existing wounds to permit exploration and repair if necessary of nerves and tendons (after Rank and Wakefield)

well recognised that incisions along the middle of the palmar aspect of a finger are contra indicated in general but given such a scar a Z-plasty can alleviate at least the contractural result

Use of the Z-plasty

Contractures The Z plasty is only useful in the well defined fairly narrow linear contracture The diffuse broad contracture requires the importation of skin by flap or graft The bow string contracture is suitable for one large Z plasty the contracture of less severe degree involving several joints requires multiple smaller Z plasties to correspond with the flexion crease of each joint

right angles should be avoided (Figs 7, 2 and 3) as contraction of the scar is liable to cause a flexion contracture

This principle applies also to grafts and flaps at least to the extent that the margin of the graft or flap should not run in an unbroken line at right angles across a crease With a graft such a marginal scar is especially liable to contract, as in most cases failure



FIG 7, 2

Commonly used incisions in the hand These may be combined or modified if necessary with the proviso that the blood supply of any flap raised must be adequate for its survival (after Furlong)

of the graft at its margin for even a millimetre or two produces a scar which gives rise to a contracture If a straight marginal line is necessary for any reason it will probably require subsequent revision with a Z-plasty inset to break the line

In the finger the lack of skin wrinkling along the lateral line shows it to be neutral as regards skin tension (Fig 7, 4) and grafts and flaps are best carried well round on to the side of the finger to bring the marginal scar into this neutral line where a minor contracture is of no consequence When a contracted scar is being excised this may mean that normal skin has to be removed

lest contraction of the marginal scar recreate the deformity the procedure was designed to relieve.

Conversely, when the side of the finger is grafted in syndactyly, the marginal scar, originally antero-lateral, tends with flexion of the finger over a period to move anteriorly further away from the neutral line and forms a contracture requiring a Z-plasty. It is

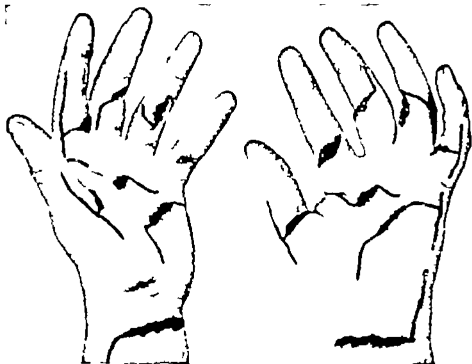


FIG. 73

Suitable incisions extending existing wound to permit exploration and repair of [illegible] nerves and tendons (after Rank and Wakefield)

well recognized that incisions along the middle of the palmar aspect of a finger are contra-indicated in general, but given such a scar a Z-plasty can alleviate at least the contractural result.

Use of the Z-plasty

Contractures. The Z-plasty is only useful in the well-defined fairly narrow linear contracture. The diffuse broad contracture requires the importation of skin by flap or graft. [illegible] contracture [illegible] suitable [illegible] one large Z-plasty [illegible] the contracture [illegible] severely [illegible] several [illegible] Z-plasties [illegible] with the [illegible]

right angles should be avoided (Figs 7, 2 and 3) as contraction of the scar is liable to cause a flexion contracture

This principle applies also to grafts and flaps at least to the extent that the margin of the graft or flap should not run in an unbroken line at right angles across a crease With a graft such a marginal scar is especially liable to contract, as in most cases failure



FIG 7, 2

Commonly used incisions in the hand These may be combined or modified if necessary with the proviso that the blood supply of any flap raised must be adequate for its survival (after Furlong)

of the graft at its margin for even a millimetre or two produces a scar which gives rise to a contracture If a straight marginal line is necessary for any reason it will probably require subsequent revision with a Z-plasty inset to break the line

In the finger the lack of skin wrinkling along the lateral line shows it to be neutral as regards skin tension (Fig 7, 4) and grafts and flaps are best carried well round on to the side of the finger to bring the marginal scar into this neutral line where a minor contracture is of no consequence When a contracted scar is being excised this may mean that normal skin has to be removed

A continuous multiple Z-plasty can often be used most effectively (Fig 7, 5)

The contracted junction of a graft and the surrounding skin can be lengthened with Z-plasties and these again should be placed to correspond with the flexure lines

Web deepening In minor degrees of syndactyly or post-burn webbing the Z-plasty can be applied to the problem of deepening



Fig 7, 4

The absence of major wrinkling along the lateral line, compared with both palm and dorsum, shows it to be neutral for skin tension

the web (Fig 7, 6) If the web is looked on as a line of contracture a Z-plasty can be carried out with a dorsal and a palmar flap Lengthening the web in this way has the effect of deepening it

Incidentally such a Z gives excellent exposure of the deep structures of the web, it allows, for example, the superficial transverse ligament of the palmar aponeurosis to be excised easily when it is severely involved in Dupuytren's contracture

Central finger scars It is particularly in dealing with the digital extension of Dupuytren's contracture that a Z-plasty of the palmar skin of the proximal phalangeal segment gives good exposure while at the same time correcting the skin contracture so often associated

Use of Free Skin Grafts

In a difficult situation where take of a graft is likely to be hazardous as with a granulating surface or in primary trauma

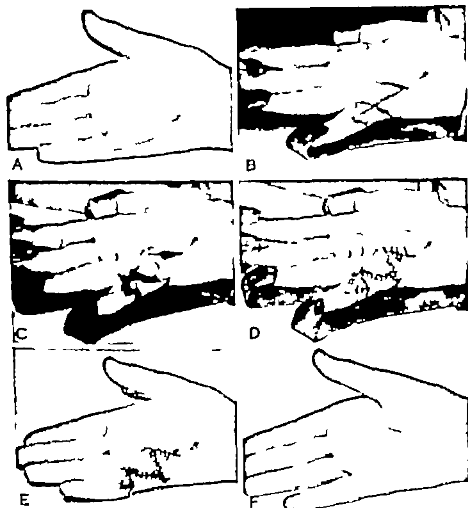


Fig 7 5

A continuous multiple Z-plasty used to correct a mild linear contracture (A) Note the designing of the Z's (B) to place the transverse limbs of the completed Z-plasty (C D E F) in skin creases See Fig 1 9

the overriding need is for successful take and the split skin graft is therefore the graft of choice regardless of site Even in the palm of hand and finger where secondary contracture is inevitable it must still be used to be replaced if necessary by a whole skin graft at a later date when conditions for take are better

It is in the uncrushed injury that grafts take most easily In the crush injury grafts take much less well probably due to an element of devitalisation insufficient to jeopardise the viability

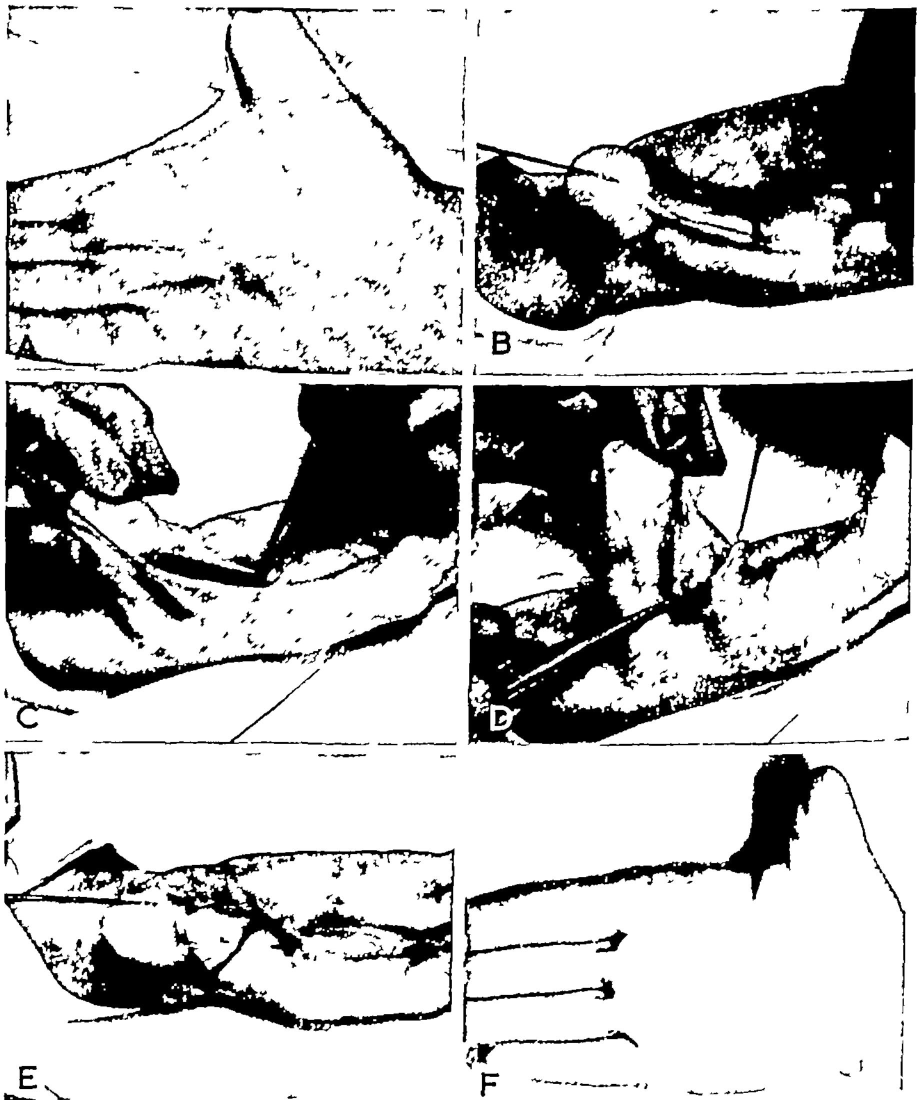


FIG 7, 6

The use of a Z-plasty in deepening the web between the thumb and index finger to increase the grasp of a thumb short as a result of trauma

of the finger but of a degree to affect adversely the vascularisation of the graft Recognition of this fact suggests the desirability of more radical debridement of the recipient site in preparation for the graft in crushing injuries

In elective surgery and the secondary repair of hand injuries the split skin graft preferably thick can be used on the dorsum On the palm between the fingers and in the webs where secondary contracture would so often destroy the whole point of the procedure a whole skin graft must be used

Although the size of a graft depends primarily on the dimensions of the defect there are occasions where it becomes desirable to carry the graft beyond the original defect even though this may mean excising normal skin The factors which determine such a procedure have been discussed in relation to the placing of scars in the hand

The method of applying and suturing the graft is similar to that described for general use When applying the tie over flavine wool and the subsequent pressure dressing care should be taken to avoid undue pressure on the graft It is the graft on dorsum of fingers and hand which is specially liable to be adversely affected by too much pressure and the prominences caused by the heads of the metacarpals and proximal phalanges are the most vulnerable areas Over these areas too graft failure is most serious for exposure of tendon and joint capsule is the inevitable result The prominences are increased by marked flexion of the fingers and so the hand should be immobilised if anything on the extended side of the position of function

The application of the dressing will be discussed under the heading of post operative care

Use of Flaps

Different sources of skin vary in the extent to which they reproduce the characteristics of the skin of the defect in sensation texture appearance etc Local skin is best followed by forearm skin with trunk skin a poor third but this aspect is only one factor to be considered in an individual case and the appropriate type of flap its source etc tends to be governed more by the size of the defect and its site

In preparing the recipient site for a flap of any kind the margin should always be excised to healthy tissue and this applies with special force to a granulating area for only with radical excision can the flap be soundly sutured to good surgical material It is

advisable on occasion to bring a flap beyond the obvious defect for the reasons mentioned in the placing of scars in the hand (page 195) Difficulties will be avoided if it is remembered in planning that the arm is at its most comfortable in the mid-prone position The more supination called for by the flap the more difficult is the position to maintain voluntarily and as fixation cannot be other than by elastoplast the most comfortable position should be chosen

The elimination of raw surface both in the hand itself and on the flap is desirable at all stages It is seldom if ever possible to

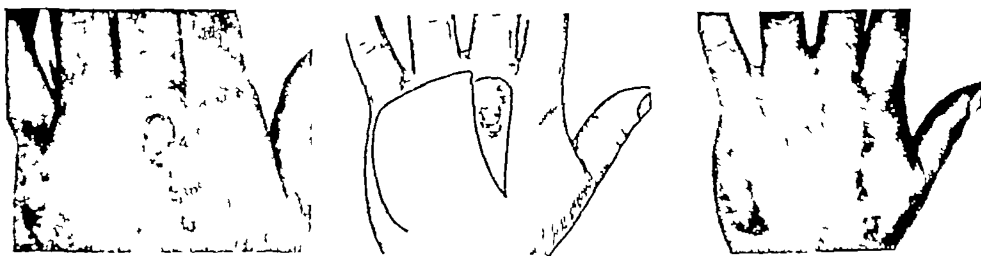


FIG 7, 7

Defect of the dorsum of the hand resulting from an electrical burn with loss of extensor tendon The transposed flap used to provide cover permitted subsequent tendon repair by extensor indicis transplant

raise a reception flap in the hand and the split-skin graft covering the donor site of the flap must be extended to line the bridge segment when a direct flap is used The tube pedicle, though it takes added time for tubing, does have the great advantage of completely eliminating raw surface quite apart from the added latitude of movement which its pedicle length permits while it is attached to the hand

When a flap is being transferred as a preliminary to a reconstructive procedure, e g of tendon, it is usually advisable to have the transfer complete and the area quite healed before the deep structure is treated so that the possibility of sepsis can be quite eliminated

Defects proximal to the webs

If a defect of the dorsum is small a rotation or transposed flap is sometimes a possible method of repair (Fig 7, 7) Free skin grafting of the secondary defect is almost universally needed as

the amount of slack available on the dorsum is deceptively small In practice cases suitable for a rotation flap seldom occur and the distant flap has a much wider usefulness Rotation flaps of the palm cannot be recommended from any point of view because of the characteristics of the skin itself and its intimate attachment to the palmar aponeurosis



Fig 7, 8

Severe palmar contracture showing initial inset of the pedicle into a neutral unscarred area in preparation for subsequent excision of scarring release of contracture and insetting of pedicle in a single procedure

The points brought out in discussing the use of direct flaps from chest and abdomen for defects of forearm apply to the hand also When a tube pedicle is used particularly for palmar defects it is worth while considering an inset of the pedicle into a neutral unscarred zone (Fig 7, 8) so that excision of the scarring can be followed by skin cover of the entire area in a single procedure For the defect of intermediate size near the radial or ulnar side a direct flap from the opposite forearm may be used The cross arm flap is discussed in more detail for cover of finger defects

Defects distal to the webs

The defect may be of one finger only or of several fingers and according to circumstances a **distant** flap from trunk or opposite forearm, or a **local** flap from adjoining finger or thenar eminence may be used for cover



FIG 7, 9

The use of a trunk flap to repair a defect of pulp of thumb

Distant flaps When a single finger is involved the decision of whether or not a trunk flap can be used depends largely on the site of the defect for the other fingers may make it impossible to bring the defect and potential flap together readily It is more for pulp replacement that a trunk flap is used (Fig 7, 9) though even here skin more near in character to normal pulp skin is preferable where a suitable flap can be constructed

Defects of several fingers may be dealt with simultaneously by suturing the adjacent margin of each defect so that one large defect is made which can then be covered with a single flap (Fig 7, 10) When the fingers come subsequently to be separated it will be found that the amount of skin needed for each finger is



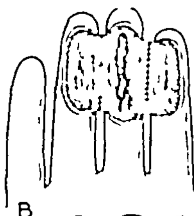











FIG 7 10

The conversion of an injury of several fingers into a single defect prior to flap cover The injury (A) of index middle and ring fingers caused by friction burning converted into a single defect (B) and covered by a direct abdominal flap (C) The flap divided (D) and the fingers separated (E) The final result (F) after thinning of the segment of the flap on each finger

greater than one might have expected The thickness of the flap makes this unavoidable even allowing for as much thinning as possible and the flap should be of correspondingly generous dimensions

The extensive defect usually requires a trunk flap (Fig 4, 17) because the alternative sources are too limited in area For the defect of intermediate size a cross-arm flap from the other forearm (Figs 7, 1 and 7, 11) is a useful method of covering either the dorsal or palmar surface of a finger The position is easy to maintain and the flap can be of the direct type if the length-breadth ratio permits When the ratio makes such a flap risky the bipedicled strap flap may be used instead The flexor aspect of the forearm is the obvious donor site but as long as the flap does not encroach on the subcutaneous border of the ulna any site which permits a comfortable position during transfer may be used

Local flaps These can be taken from an adjoining finger or the thenar eminence as cross-finger and thenar flaps

Cross-finger flap (Figs 7, 12, 7, 13 and 7, 14) This type of flap can provide cover for a defect of the palmar aspect of a finger, particularly in the middle and proximal phalangeal segments, since it can only be taken from the dorsum and side of the donor finger It is most useful for defects of between one and two phalangeal segments Smaller defects increase the length-breadth ratio while the technical difficulties increase if the area to be covered is much longer than this The flap finds one of its most effective uses in covering the thumb Whether pulp or tip is being covered the thumb can readily be positioned so that the flap from index finger is not under tension and its pedicle is not subject to undue torsion

The flap must be raised with care to avoid baring the digital nerve and artery or extensor expansion and the secondary defect on the donor finger is covered with a thick split-skin graft

---

Fig 7, 11

The use of a cross-arm flap in repairing an injury of the thenar eminence The injury (A), involving the metacarpo-phalangeal joint, prepared (B) to receive the flap The flap outlined (C), and raised (D) The split-skin graft applied to the secondary defect (E) showing the extension of the graft (F) to line the pedicle segment of the flap (G) and the plaster of Paris fixation of the arms (H) The flap immediately before division (I), and divided and inset (J) The final result (K)




















K



greater than one might have expected The thickness of the flap makes this unavoidable even allowing for as much thinning as possible and the flap should be of correspondingly generous dimensions

The extensive defect usually requires a trunk flap (Fig 4, 17) because the alternative sources are too limited in area For the defect of intermediate size a cross-arm flap from the other forearm (Figs 7, 1 and 7, 11) is a useful method of covering either the dorsal or palmar surface of a finger The position is easy to maintain and the flap can be of the direct type if the length-breadth ratio permits When the ratio makes such a flap risky the bipedicled strap flap may be used instead The flexor aspect of the forearm is the obvious donor site but as long as the flap does not encroach on the subcutaneous border of the ulna any site which permits a comfortable position during transfer may be used

Local flaps. These can be taken from an adjoining finger or the thenar eminence as cross-finger and thenar flaps

Cross-finger flap (Figs 7, 12, 7, 13 and 7, 14) This type of flap can provide cover for a defect of the palmar aspect of a finger, particularly in the middle and proximal phalangeal segments, since it can only be taken from the dorsum and side of the donor finger It is most useful for defects of between one and two phalangeal segments Smaller defects increase the length-breadth ratio while the technical difficulties increase if the area to be covered is much longer than this The flap finds one of its most effective uses in covering the thumb Whether pulp or tip is being covered the thumb can readily be positioned so that the flap from index finger is not under tension and its pedicle is not subject to undue torsion

The flap must be raised with care to avoid baring the digital nerve and artery or extensor expansion and the secondary defect on the donor finger is covered with a thick split-skin graft

---

Fig 7, 11

The use of a cross-arm flap in repairing an injury of the thenar eminence The injury (A), involving the metacarpo-phalangeal joint, prepared (B) to receive the flap The flap outlined (C), and raised (D) The split-skin graft applied to the secondary defect (E) showing the extension of the graft (F) to line the pedicle segment of the flap (G) and the plaster of Paris fixation of the arms (H) The flap immediately before division (I), and divided and inset (J) The final result (K)



G

B

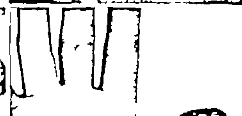
H

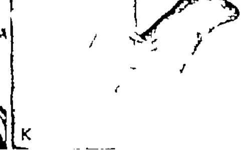
C

I

D

J

E


F

K

The reach of a cross-finger flap can be increased if a point is made of dividing Cleland's skin ligaments These ligaments as they appear in this surgical procedure form a fibrous septum just dorsal to the neuro-vascular bundle and bind the skin of the neutral

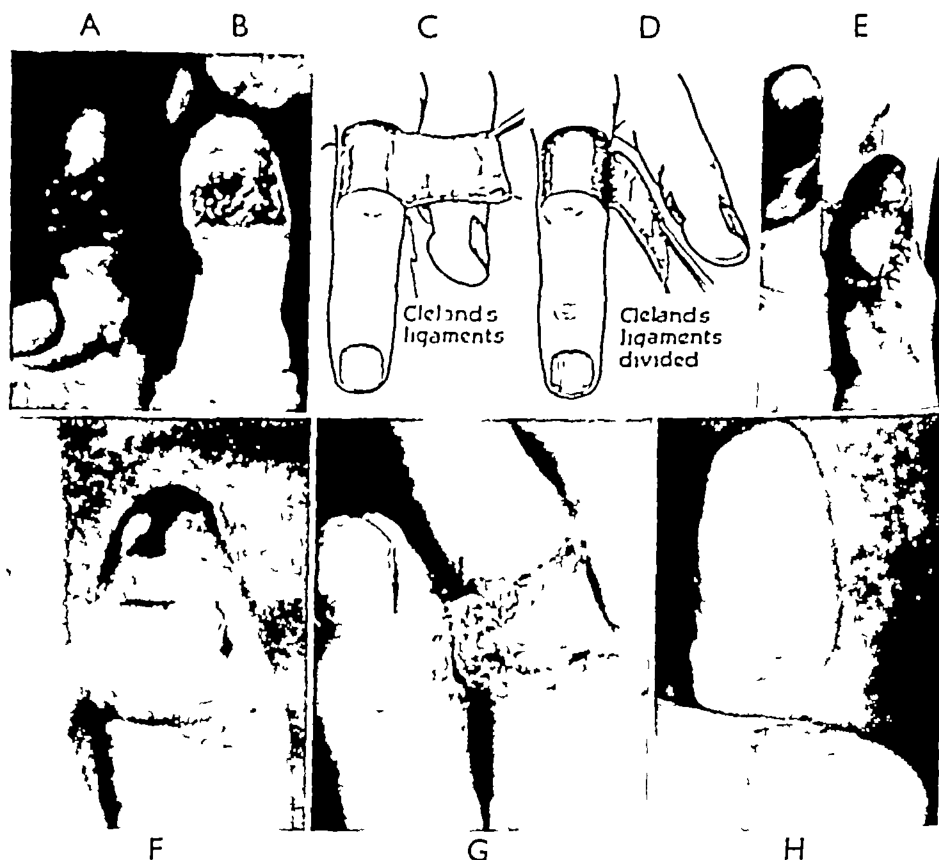


FIG 7, 12

A cross-finger flap used to resurface the pulp of thumb The injury (A), prepared to receive the flap (B) The flap raised before (C), and after (D), incising Cleland's ligaments, and sutured in position (E) The flap (F) and the split-skin graft applied to the secondary defect (G) shortly before dividing the pedicle The final result (H)

line to the side of each phalanx Their division frees the skin of the neutral line and adds greatly to the mobility and reach of the flap itself

A modification of the cross-finger flap as described can be used to resurface the tip of a finger when the relative lengths of donor and recipient fingers are suitable and the mobility of the recipient finger adequate (Fig 7, 15) It is important to avoid encroaching on the nail bed of the donor finger when the flap is constructed

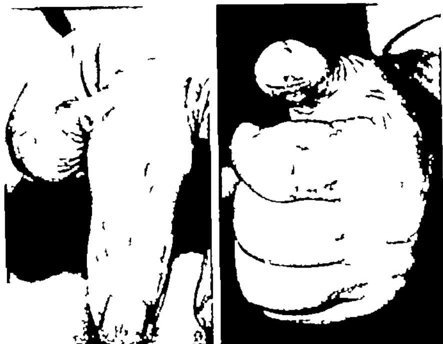


FIG 7 13

A cross finger flap used to preserve length in a traumatic partial amputation of thumb This type of flap can only be used readily when the thumb has already been shortened and with its twist of pedicle it must be planned with great care

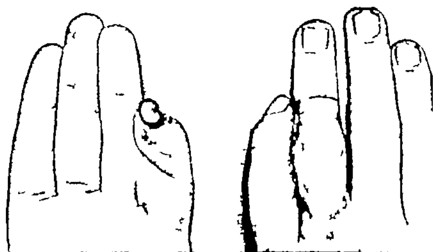


FIG 7 14

A cross finger flap used to resurface the palmar aspect of almost the whole length of the fifth finger This is as wide a flap as can safely be used

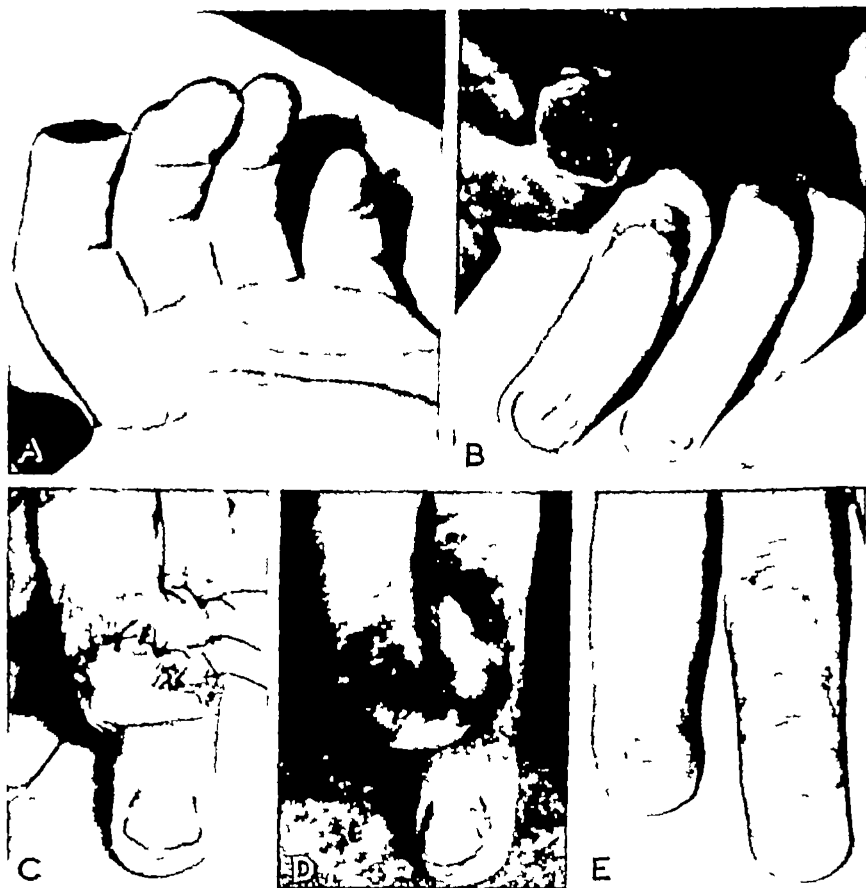


FIG 7, 15

The distally based cross-finger flap used to cover a guillotined index finger-tip The injury (A) and the flap (B), sutured in position with a split-skin graft applied to the secondary defect (C) The dressing 14 days later (D), and the end result (E)

This is a common injury and when the preservation of length of the finger is considered desirable the flap is a most useful one The distal basing of the flap does not jeopardise its viability

The index finger is the one which most often sustains an injury requiring this particular flap

Thenar flap It is well-recognised that flexion of any of the four

---

FIG 7, 16

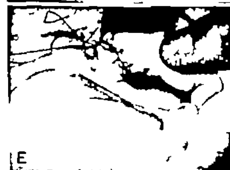
The use of a thenar flap to repair a defect (A) of pulp of finger The defect is displayed fully (B) by excising marginal scarring and the flap is outlined with Bonney's Blue (C) on the thenar eminence, elevated (D), and sutured to the defect (E) A split-skin graft is sutured to the secondary defect (F) and a tie-over dressing (G) is applied The flap is shown just before (H) and after (I), division of the pedicle and insetting of the flap The final result (J)

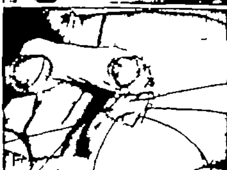


















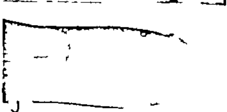


FIG 7 16



FIG 7, 15

The distally based cross-finger flap used to cover a guillotined index finger-tip The injury (A) and the flap (B), sutured in position with a split-skin graft applied to the secondary defect (C) The dressing 14 days later (D), and the end result (E)
This is a common injury and when the preservation of length of the finger is considered desirable the flap is a most useful one The distal basing of the flap does not jeopardise its viability

The index finger is the one which most often sustains an injury requiring this particular flap

Thenar flap It is well-recognised that flexion of any of the four

---

FIG 7, 16

The use of a thenar flap to repair a defect (A) of pulp of finger The defect is displayed fully (B) by excising marginal scarring and the flap is outlined with Bonney's Blue (C) on the thenar eminence, elevated (D), and sutured to the defect (E) A split-skin graft is sutured to the secondary defect (F) and a tie-over dressing (G) is applied The flap is shown just before (H) and after (I), division of the pedicle and insetting of the flap The final result (J)

in padding is to convert the hand into a cylinder so that pressure is evenly distributed Failure to pad the palm and dorsum adequately causes undue pressure on the radial and ulnar sides and sores may result Only the finger tips are left visible to indicate the vascular state of the hand



FIG 7 17

The plaster of Paris cast applied post-operatively

When no graft has been used absolute immobilisation may be less necessary and the regime can be suitably relaxed

Prevention of oedema

Oedema fluid provides the raw material of stiff fingers and is prevented by elevation When a graft has been applied or there has been extensive soft tissue dissection the hand should be elevated preferably in plaster of Paris

A well padded cast should encircle the arm as far proximally as the upper humerus (Fig 7, 17) so that the weight is taken on the upper arm and *not* on the wrist and hand In more minor procedures elevation on a pillow or in a sling without plaster of Paris is adequate

fingers brings its pulp to almost the same point of the thenar eminence and this fact can be used in resurfacing pulp or finger-tip defects by a flap raised on the thenar eminence (Fig 7, 16) The flap has its main use in the hand with relatively thin palmar skin, the calloused hand of the manual worker is quite unsuited for the procedure If the patient is unable to bring the finger requiring cover to lie against the thenar eminence easily and with a complete absence of discomfort the flap should never be contemplated This excludes it as a rule from being considered for the index and fifth fingers

The dimensions and site of the defect determine how the flap should be based For a defect of the greater part of the pulp a side-based flap offers the best length-breadth ratio The secondary defect is covered with a thick split-skin graft

Planning with jaconet, so effective elsewhere, does not work well with the thenar flap The blood-stained imprint of the flexed finger is more useful in giving the appropriate site and shape of the flap to be raised

This flap has its enthusiastic advocates but it is not without unsatisfactory aspects A tender scar in the thenar area is a serious disability and occasionally occurs, and the finger immobilised in flexion for the period necessary is sometimes difficult to mobilise In addition it is difficult to avoid maceration of skin in the operative site from the close proximity of flap and palm for the area sweats virtually continuously at ordinary temperatures It is a flap to use sparingly and only when the indications are clear

POST-OPERATIVE CARE

Following a surgical procedure in the hand a period of immobilisation is generally desirable and this is provided by the dressing on occasion reinforced by plaster of Paris At the same time measures should be taken to prevent oedema developing in the hand

Dressing of the hand

If a graft has been applied it is usually wise, regardless of the site of the graft, to immobilise the entire hand in the position of function Following the tie-over dressing careful padding of the whole hand, in the webs and between the fingers, must be carried out before applying the circumferential crepe bandages The aim

in padding is to convert the hand into a cylinder so that pressure is evenly distributed Failure to pad the palm and dorsum adequately causes undue pressure on the radial and ulnar sides and sores may result Only the finger tips are left visible to indicate the vascular state of the hand



FIG 7 17

The plaster of Paris cast applied post-operatively

When no graft has been used absolute immobilisation may be less necessary and the regime can be suitably relaxed

Prevention of oedema

Oedema fluid provides the raw material of stiff fingers and is prevented by elevation When a graft has been applied or there has been extensive soft tissue dissection the hand should be elevated preferably in plaster of Paris

A well padded cast should encircle the arm as far proximally as the upper humerus (Fig 7, 17) so that the weight is taken on the upper arm and *not* on the wrist and hand In more minor procedures elevation on a pillow or in a sling without plaster of Paris is adequate

Subsequent dressings

Unless there is a good reason most dressings in hand injuries should be left untouched for a week and many can safely be left for longer The less the injury and dressings are interfering with hand function the less the need for early dressing and, if there are no clinical signs to suggest infection, the first dressing can often be left until the tenth to twelfth day This applies even to the injury involving a graft When the function of the hand is significantly limited by the dressings, particularly in older patients, the first dressing should generally be done on the seventh day and the bulk of dressings thereafter should be reduced to a minimum so that movement of the fingers can be instituted as rapidly and intensively as possible

A similar approach applies to the dressing following elective procedures

BIBLIOGRAPHY

Hand injuries

EVANS, E M (1949) The treatment of major injuries of the hand *Brit J plast Surg* 2, 150

FURLONG, R (1957) *Injuries of the Hand* London J & A Churchill

RANK, B K & WAKEFIELD, A R (1953) *Surgery of Repair as applied to Hand Injuries* Edinburgh E & S Livingstone

REID, D A C (1956) Experience of a hand surgery service *Brit J plast Surg* 9, 11

Finger-tip injuries

BARCLAY, T L (1955) The late results of finger-tip injuries *Brit J plast Surg* 8, 38

FLATT, A E (1955) Nail-bed injuries *Brit J plast Surg* 8, 34

Cross-arm flaps

McCASH, C R (1956) Cross-arm bridge flaps in the repair of flexion contractures of the fingers *Brit J plast Surg* 9, 25

Cross-finger and thenar flaps

CURTIS, R M (1957) Cross-finger pedicle flap in hand surgery *Ann Surg* 145, 650

FLATT, A E (1957) The thenar flap *J Bone Jt Surg* 39B, 80

TEMPEST, M N (1954) The emergency treatment of digital injuries *Brit J plast Surg* 7, 153

CHAPTER EIGHT

Surgery of the Eyelids

SKIN cover of the eyelids is usually required as a result of loss from trauma or surgical excision for malignancy

EYELID INJURIES

The extremely rich blood supply of the eyelids permits survival of flaps with the most tenuous of attachments It follows that the approach to the treatment of trauma in this region must be ultra conservative wound excision should be minimal and the surgeon s chief aim should be to replace tissues in their proper anatomical site (Fig 8, 1) The severely damaged eyelid may present a veritable jig saw puzzle but reassembling the various parts correctly is not labour wasted even if secondary operations are required to correct skin or deep contractures they will be easy and successful in direct proportion to the care taken and the accuracy achieved at the primary operation

When an eyelid injury is first seen there often appears to be actual loss of tissue but the true loss can be assessed only as the repair proceeds and is almost always less than at first seemed likely In repairing these injuries there are certain key structures which correctly placed as a first step can act as landmarks

Tear duct system When the lower lid canaliculus has been severed it is desirable to reconstitute it where possible Failure to do so may result in an intractable epiphora and late reconstruction is not possible A careful search should be made for the cut end leading to the lacrimal sac but if it cannot be found passage of a nylon thread or probe through the canaliculus of the intact lid and lacrimal sac will sometimes help in identifying it (Fig 8, 1) In the same way if the segment in the lid cannot be seen passage of a nylon or silk worm gut thread through the punctum will show the cut end of the canaliculus where it emerges Passage of the thread

into the other orifice will allow healing in continuity This procedure is easier to describe than carry out but it is worth attempting where possible The tendency to stricture even when the canaliculus is reconstituted is marked and despite

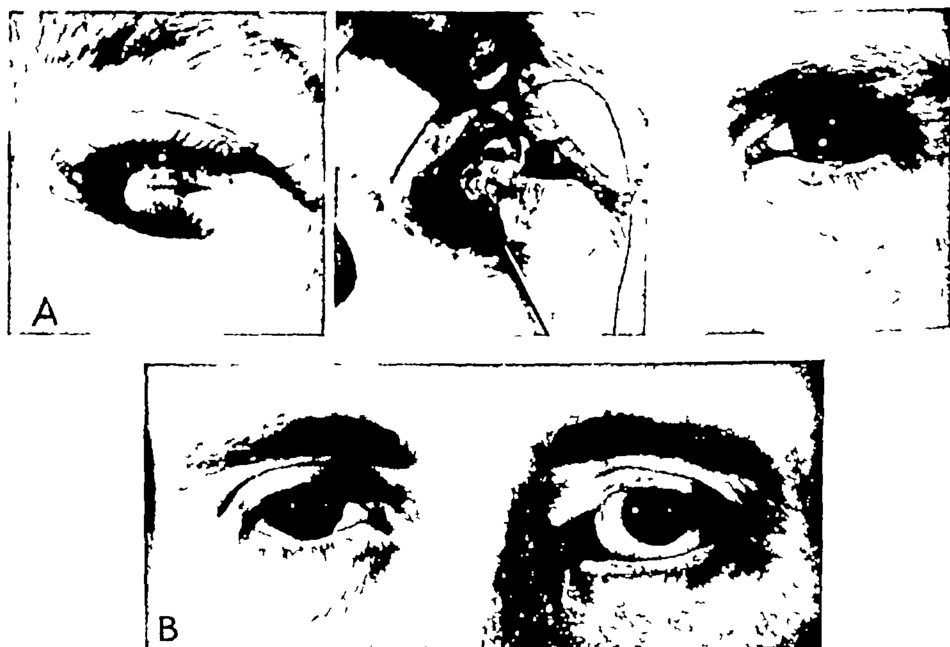


FIG 8, 1

A Repair of an injury without tissue loss avulsing the lower lid from its medial attachment, showing an attempt to restore the continuity of the canaliculus by threading monofilament nylon through the lacrimal punctum and into the lacrimal sac

The final result shows the excellent appearance which can be achieved by accurate reconstitution of the medial canthus

B The result of failure to reconstruct the canthus accurately following an injury similar to A

The repair of an injury similar to A as part of a more extensive facial soft tissue injury is shown in Fig 1, 10

passage of probes drainage of tears is often poor Fortunately even with complete failure to reconstitute the canaliculus the epiphora is not invariably severe

Lid margin Various methods of stepping incisions or wounds of the lid margin have been described but careful matching is quite adequate if the wound edge is made to evert a little by the suture In any case it would be quite unjustifiable to traumatise still further tissues already damaged by the injury The various landmarks of the lid margin—the eyelashes, the

grey line the junction of conjunctiva and skin all can be used for matching purposes

Tarsal plates In each eyelid the tarsal plate is closely adherent to the conjunctiva and in trauma the two behave as a single structure It is advisable where possible to avoid sutures in the conjunctiva but matching of the tarsal plates can be used to fix the margins of the associated conjunctiva which in any case heals very rapidly

Conjunctiva At the completion of any repair it is essential to have a situation which will permit cover of the cornea with lid conjunctiva during sleep and a tarsorrhaphy is sometimes



Fig 8 2

The interweaving suture (after Stallard)

needed to ensure this Sutures of the conjunctiva cause irritation of the cornea where the two come into contact they are difficult to remove and are best avoided When they cannot be avoided a continuous interweaving suture (Fig 8, 2) brought out to the skin surface at each end is useful It draws the conjunctiva together well there is no interlocking and it is readily removed The smooth surface of nylon thread can be turned to advantage in this situation for easy removal

Palpebral ligaments The tarsal plates which give to the eyelids such rigidity as they possess have their main attachment to the bony orbit via the medial and lateral palpebral ligaments and if either of these ligaments has been divided traumatically it must be reconstituted as far as possible by suture The medial ligament is the more powerful structure and damage to it is correspondingly serious for the whole medial canthal region drifts forward and laterally giving the appearance of a unilateral hypertelorism It is stated that this appearance only results if the posterior attachment of the ligament behind the lacrimal sac is divided but at least as far as trauma is concerned this is largely an academic point

Unfortunately it is extremely difficult to reconstitute the

into the other orifice will allow healing in continuity This procedure is easier to describe than carry out but it is worth attempting where possible The tendency to stricture even when the canaliculus is reconstituted is marked and despite

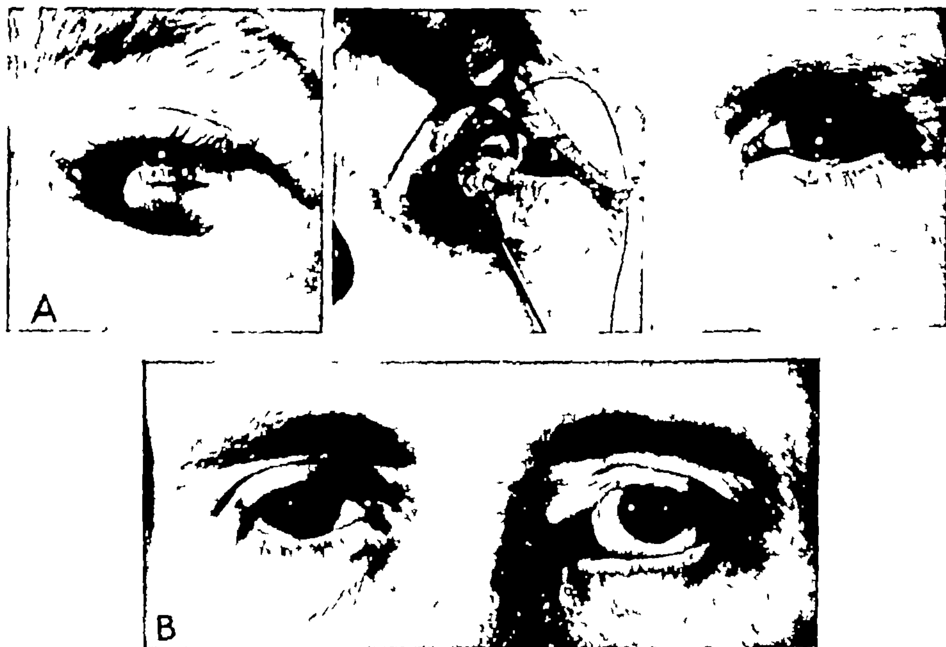


Fig 8, 1

A Repair of an injury without tissue loss avulsing the lower lid from its medial attachment, showing an attempt to restore the continuity of the canaliculus by threading monofilament nylon through the lacrimal punctum and into the lacrimal sac

The final result shows the excellent appearance which can be achieved by accurate reconstitution of the medial canthus

B The result of failure to reconstruct the canthus accurately following an injury similar to A

The repair of an injury similar to A as part of a more extensive facial soft tissue injury is shown in Fig 1, 10

passage of probes drainage of tears is often poor Fortunately even with complete failure to reconstitute the canaliculus the epiphora is not invariably severe

Lid margin Various methods of stepping incisions or wounds of the lid margin have been described but careful matching is quite adequate if the wound edge is made to evert a little by the suture In any case it would be quite unjustifiable to traumatise still further tissues already damaged by the injury The various landmarks of the lid margin—the eyelashes, the

grey line the junction of conjunctiva and skin all can be used for matching purposes

Tarsal plates In each eyelid the tarsal plate is closely adherent to the conjunctiva and in trauma the two behave as a single structure It is advisable where possible to avoid sutures in the conjunctiva but matching of the tarsal plates can be used to fix the margins of the associated conjunctiva which in any case heals very rapidly

Conjunctiva At the completion of any repair it is essential to have a situation which will permit cover of the cornea with lid conjunctiva during sleep and a tarsorrhaphy is sometimes



FIG 8 2

The interweaving suture (after Stallard)

needed to ensure this Sutures of the conjunctiva cause irritation of the cornea where the two come into contact they are difficult to remove and are best avoided When they cannot be avoided a continuous interweaving suture (Fig 8 2) brought out to the skin surface at each end is useful It draws the conjunctiva together well there is no interlocking and it is readily removed The smooth surface of nylon thread can be turned to advantage in this situation for easy removal

Palpebral ligaments The tarsal plates which give to the eyelids such rigidity as they possess have their main attachment to the bony orbit via the medial and lateral palpebral ligaments and if either of these ligaments has been divided traumatically it must be reconstituted as far as possible by suture The medial ligament is the more powerful structure and damage to it is correspondingly serious for the whole medial canthal region drifts forward and laterally giving the appearance of a unilateral hypertelorism It is stated that this appearance only results if the posterior attachment of the ligament behind the lacrimal sac is divided but, at least as far as trauma is concerned this is largely an academic point

Unfortunately it is extremely difficult to reconstitute the

ligamentous attachment and though the immediate post-operative position of the lids following wiring, etc, of the ligament to its bony insertion may be good, the system tends to drift back to its pre-operative position

USE OF GRAFTS

Ideally a graft replacing eyelid skin must fulfil certain requirements which arise from the functional anatomy of the region Firstly, the lack of rigidity of the normal tarsal plate makes the eyelids prone to cicatrical ectropion or entropion if there is the slightest contracture on the surface of the lid or in the socket Secondly, eyelid skin is extremely thin and in the upper lid particularly is only loosely attached deeply because of the need for rapid movement of the eyelids The lower eyelid is less mobile than the upper and the part of the upper lid corresponding to the tarsal plate is in its turn less mobile than that above the upper palpebral furrow

Skin grafted to an eyelid should be as thin as normal eyelid skin, especially when the most mobile skin is being replaced, and in addition should be free of a tendency to secondary contraction Unfortunately the best skin, which comes from the upper eyelid, is extremely limited in quantity at best and may not be available at all and so a compromise has generally to be reached (Fig 8, 3) For less mobile areas, the canthi, the lower eyelid and the tarsal segment of the upper eyelid, post-auricular whole thickness skin provides the best substitute, gives an excellent colour and texture match, and its extreme vascularity makes take easy

In the upper part of the upper eyelid, the need for extreme mobility is paramount and a thin split-skin graft from the anterior or medial aspect of the upper arm is usually used With the knowledge that such a graft will undergo gross secondary contraction, the defect is stretched to its maximum and indeed over-corrected so that the largest possible area of skin can be inserted in expectation of secondary contraction Despite this, the graft area nearly always does end up a little shorter than normal in the vertical dimension

Preparation for grafting

Following surgical excision and immediately following trauma, the actual skin defect is already visible, but in the late repair of



FIG 8, 3

The free skin grafts used in the various eyelid sites

A. Post burn ectropion of both eyelids Upper lid skin replaced by split skin from upper arm and lower eyelid skin replaced by post-auricular whole thickness skin

B Rodent ulcer of medial canthus involving the caruncle and adjoining eyelids replaced after excision by post-auricular whole thickness skin

C Rodent ulcer of skin overlying the upper tarsal plate replaced after excision by post-auricular whole thickness skin

trauma, the defect usually shows as ectropion and must be demonstrated afresh as a raw surface so that it may be corrected

If the skin loss has been localised the scarred area is well delineated and can be dealt with, excising the scarring so that the eyelid may lie against the eyeball When the resulting defect is in the upper part of the upper eyelid and a split-skin graft is felt to be appropriate additional transverse incisions medially and laterally beyond the area of actual scarring are advisable so that the original defect may be over-corrected to allow for the

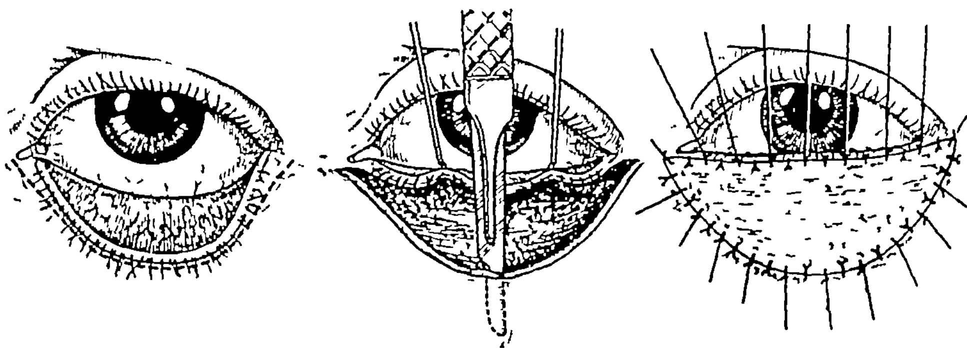


FIG 8, 4

The method of correcting diffuse ectropian of the lower eyelid and the insertion of a post-auricular whole skin graft

subsequent contraction of the graft When a post-auricular whole skin graft is felt to be adequate such over-correction is less necessary

The ectropion which results from a full thickness skin loss burn is more diffuse and to demonstrate the extent of the skin lost a different method is used (Fig 8, 4) With skin hooks on the lid margin to put the skin on the stretch, an incision is made approximately 2 mm on the skin side of the eyelashes and parallel to them If the contracture has distorted the canthus, and the lateral is the one liable to be pulled off the eyeball, the incision should be prolonged beyond it, so that any skin loss in a transverse as well as a vertical direction may be corrected An incision confined to the actual lid margin in such circumstances tends to leave slight residual ectropion towards the canthus

Maintaining tension on the hooks, the knife blade is worked away from the lid margin parallel to and just deep to the skin surface separating skin from underlying muscle As dissection proceeds the ectropion becomes increasingly corrected and the skin

defect displayed The lid should be freed until it lies spontaneously against the eyeball along its entire length and can readily be stretched well over its fellow eyelid Even after extensive freeing the lid may still tend to lie off the globe and this is generally due to residual areas of scarring in the orbicularis muscle These patches of scarring are felt rather than seen and must be excised completely with fine scissors Even what would seem to be a most radical excision of much of the muscle leaves no disability only if the levator palpebrae superioris is divided will there be ptosis The undermining of the lid margin for a millimetre or so to give a good suture line completes the preparation for the graft

The extent of the defect of eyelid made surgically is usually governed by pathological considerations but on occasion additional normal skin has to be excised to give a better line to the junction of graft and surrounding skin An example of such a situation is the extending of excision a little beyond the canthus if the junction of graft and surrounding eyelid is approaching it Also just as straight vertical scars from the lid margin are best avoided lest contraction of the scar cause ectropion a vertical junction of graft and eyelid is undesirable When it is unavoidable the defect should be fully displayed so that the maximum of skin can be inserted to allow for any subsequent contraction

The application of the graft

The method of applying a whole skin graft differs only in minor details from elsewhere It is safer to suture away from the eyeball though this may mean suturing from a less to a more mobile structure and the sutures along the eyelid margin should not be tied too tightly as they cut through readily In the same way the sutures tied over the flavine wool bolus should not put too much strain on the sutures Undue pressure is not necessary these grafts take very readily if haematoma is avoided

With a split skin graft the same technique of applying the graft can be used but the object is to stretch the defect to allow as much skin as possible to be inserted and the flavine wool technique does not lend itself readily to this The stretching and over-correction is better achieved using the STENT mould technique (Fig 8, 5) STENT is a dental moulding compound which softens to malleability in hot water and hardens to rigidity in cold and it can be used to take an accurate impression of the

stretched defect The graft is draped over the mould with its raw surface outwards so that it completely covers the surface of

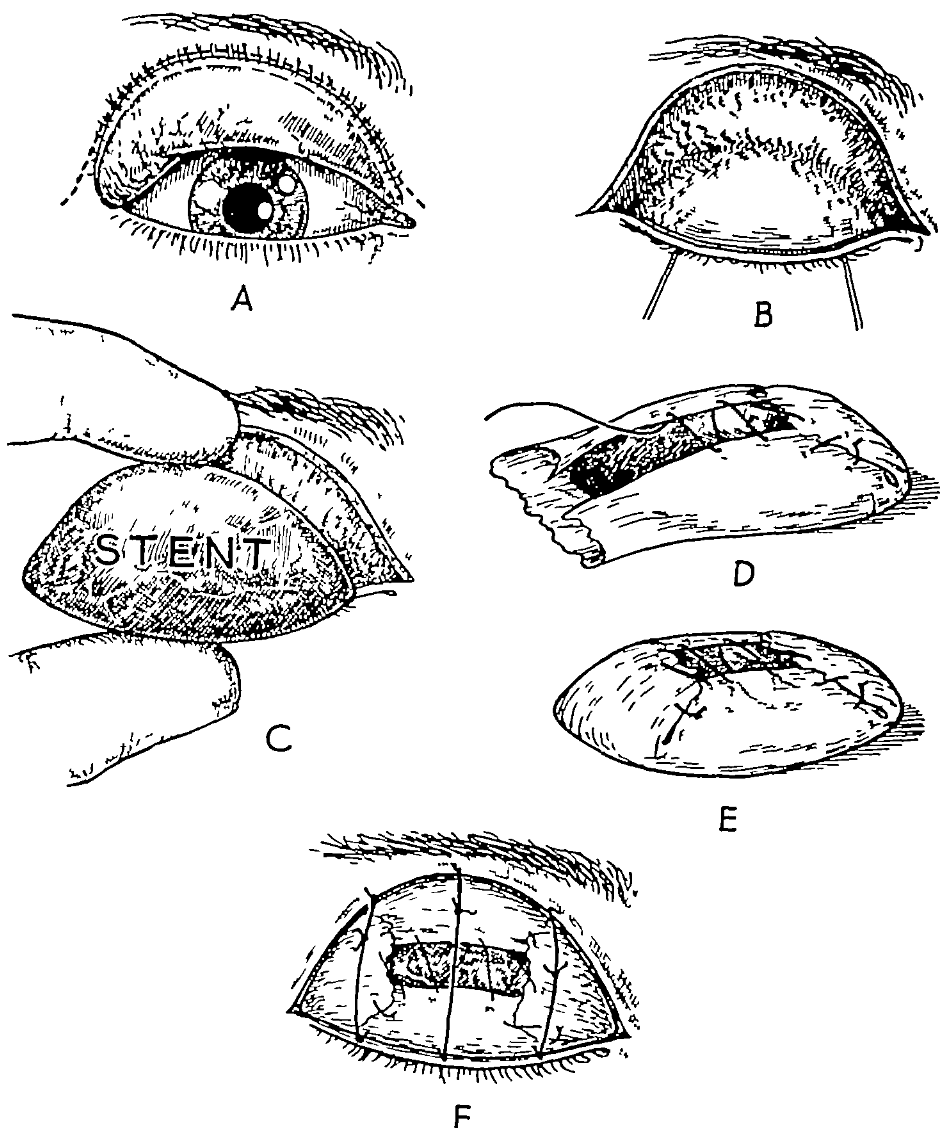


FIG 8, 5

The STENT technique of grafting an eyelid The ectropion of upper lid (A) is corrected (B) and a STENT mould (C) of the defect is made The split-skin graft with raw surface outwards is draped round the mould (D and E) and inserted into the defect (F)

the mould which is going to be inserted into the defect The mould with skin is then laid into the raw area Sutures through the skin edges of the defect are tied over the mould half-burying it so that the maximum contact of raw surface and graft is obtained

and in this way the maximum of graft is inserted. There is no question of suturing the graft edge to edge to the defect. Any obvious excess is trimmed off when the tie over sutures are tied; the graft takes to the margin of the defect and at the first dressing, usually 7 days later, the skin beyond the edge of the defect, dry and papery by now, is easily trimmed off.

Before the dressing is applied it is always advisable with either technique to "vaseline" the eyelashes away from the eyeball. To distribute pressure the dressing is built up around the flavine wool or mould and a crepe bandage is applied. Unless it is felt that movement of the eyeball underneath will irritate the cornea, and with a simple graft of skin alone this is seldom true, there is no need to cover the other eye. Some surgeons carry out a temporary tarsorrhaphy simultaneously, but this is quite unnecessary.

Post-operative care

Apart from failure of the graft to take, and this fortunately is extremely rare, the only complication to be feared is corneal ulceration and this is usually the result of trichiasis which has not been dealt with immediately. The patient must be specifically asked if he feels anything in his eye and a positive reply is an absolute indication to take down the dressing and inspect the eye for the offending eyelash. This applies regardless of the consequences to the graft though fortunately take and vascularisation are so rapid that the graft is seldom jeopardised by a careful inspection. Patients occasionally complain of some pain but give a negative reply to the direct question about the feeling of a foreign body. In such cases there is seldom need to take down the dressing; gentle easing of the bandage is usually adequate.

The graft is dressed on the seventh day and a further dressing is often wise for a further week or so, not so much to provide pressure as immobility. The lids are so mobile that even after a 100 per cent take some loss may occur if unlimited lid movements are allowed too soon.

USE OF FLAPS

When a full thickness defect of eyelid has to be repaired a flap may be necessary for skin cover, but for skin replacement alone it is less often used. Following excision of a malignant lesion

it is not easy to justify its use if skin alone is involved, though on grounds other than pathological it will give an entirely adequate result A flap can be most useful, however, in the awkwardly

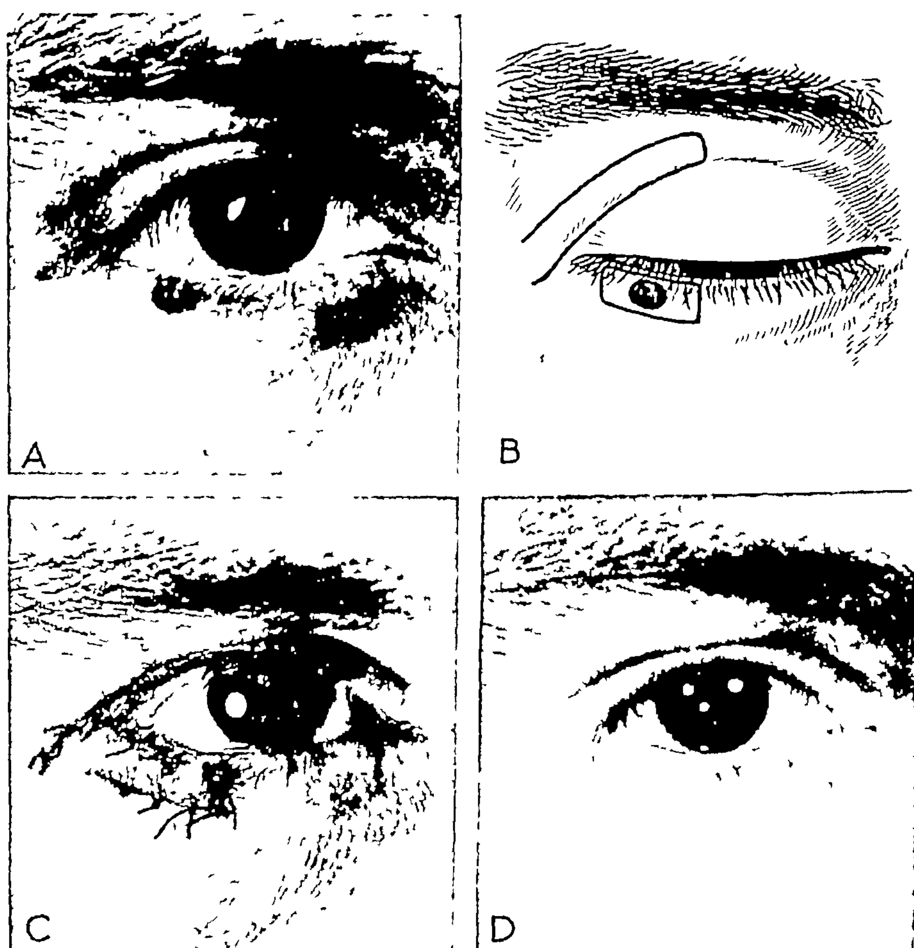


FIG 8, 6

The use of a single pedicled flap from upper eyelid in covering the defect left after excising a pigmented papilloma near the lid margin

A The lesion
B The flap outlined
C The flap transferred
D The final result after excision of the bridge segment

placed simple lesion whose excision leaves a defect Papillomata near the lid margin, for example, often require more than minimal clearance to prevent recurrence and leave a raw area which cannot readily be closed by direct suture

Lower lid defects are particularly amenable to flap repairs and the results are functionally excellent because the bulk of eyelid

movement is by the upper eyelid and a localised deficiency of orbicularis has little effect on function When the defect does not extend beyond the eyelid on to the cheek a flap of skin from the upper eyelid above the upper palpebral furrow can be used (Fig 8, 6) The vascularity of the region permits a flap of quite outrageous length breadth ratio to be used and depending on the length site etc of the defect the flap may be used with a single pedicle at either canthus or swung down as a bipedicled strap flap When the defect does not extend to the canthus the flap may be used as a bridge pedicle and the unused segment which very rapidly tubes itself can either be returned to its donor site or excised whichever is more convenient These repairs are most often needed in the older age groups and the added laxity of the upper eyelid which so often goes with age makes closure of the secondary defect easier If the secondary defect can be closed by direct suture without producing ectropion this is the course to pursue If not a split skin graft must be used

When the defect extends beyond the confines of the lower lid a broader flap is needed and the forehead is the usual source for the medial canthal region a glabellar type of flap can be used (Fig 5, 16) for the lateral canthus and the remainder of the lower lid a temporal flap is suitable (Fig 8 7)

There is a moderate amount of skin available in the upper eyelid for closure by direct suture without producing ectropion and flaps are less often needed

FULL-THICKNESS EYELID DEFECTS

The levator mechanism is of extreme importance in the normal functioning of the eyelids and its loss makes it difficult or impossible for the upper eyelid to be raised sufficiently to expose enough cornea for normal vision The lower eyelid takes part to a much smaller extent in eyelid activity and loss of its movement does not produce a significant disability

This difference in the functional importance of the upper and lower eyelids is reflected in the relative ease of reconstructing each and in the excellence of function and appearance of the reconstructed lid Reconstruction of a lower lid is relatively straight forward and the results are on the whole good Reconstruction

it is not easy to justify its use if skin alone is involved, though on grounds other than pathological it will give an entirely adequate result A flap can be most useful, however, in the awkwardly

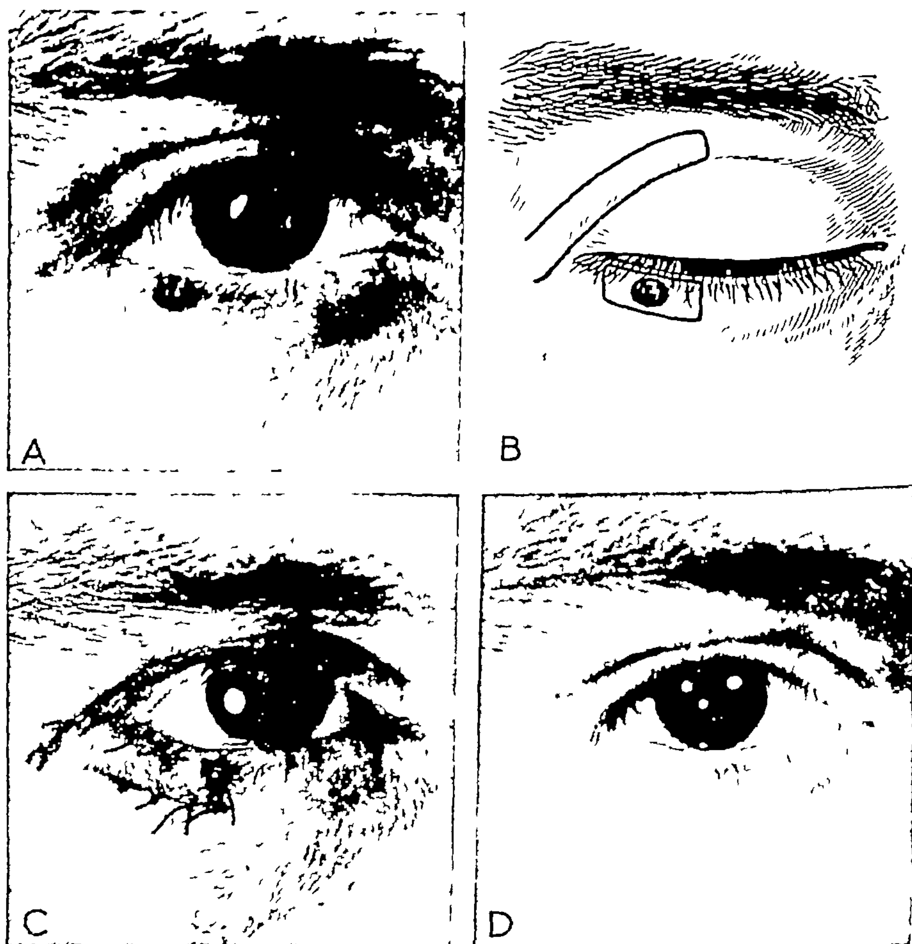


FIG 8, 6

The use of a single pedicled flap from upper eyelid in covering the defect left after excising a pigmented papilloma near the lid margin

A The lesion
B The flap outlined
C The flap transferred
D The final result after excision of the bridge segment

placed simple lesion whose excision leaves a defect Papillomata near the lid margin, for example, often require more than minimal clearance to prevent recurrence and leave a raw area which cannot readily be closed by direct suture

Lower lid defects are particularly amenable to flap repairs and the results are functionally excellent because the bulk of eyelid

of an upper eyelid is much more complicated and the excellence of the result depends largely on the extent to which levator function can be preserved From this it follows that reconstruction of a partial defect is much more successful than that of an entire upper eyelid

In view of the difficulty of reconstructing the entire upper eyelid and the generally poor results both functionally and cosmetically it is fortunate that its relative immunity to neoplasia compared with the lower eyelid and the excellent protection afforded it by the overhanging orbital margin make total recon struction either because of surgical excision or trauma seldom necessary

The Lower Eyelid

The repair of a full thickness defect is similar in principle whether the whole width of the eyelid or a segment only is involved for in each case the problem is one of providing conjunctival lining and skin cover

Conjunctival lining Beyond the inferior margin of the tarsal plate of the lower lid and round the fornix to the limbus the conjunctiva both of lid and globe is only loosely attached and is readily dissected free as a layer which can be advanced rotated etc as necessary to provide lining where it is needed With a partial lid defect of small extent the conjunctiva in the region of the fornix can be mobilised and advanced to the level of the lid margin on either side When a major segment of the eyelid has to be reconstructed the conjunctiva over the whole length of the defect can be similarly advanced to form lining Depending on whether or not any lid conjunctiva at all is available the conjunctiva of the globe may have to be undermined all the way up to the limbus and advanced to line the reconstructed eyelid This although it virtually obliterates the fornix gives rise to no functional disability

The partial defect (Fig 8 8)

With the conjunctiva advanced to be used as lining skin cover is provided by a flap single or bipedicled according to the length required brought down from the upper eyelid as already described The inclusion of any eyebrow hairs in the flap is to be avoided as they are prone to cause trichiasis

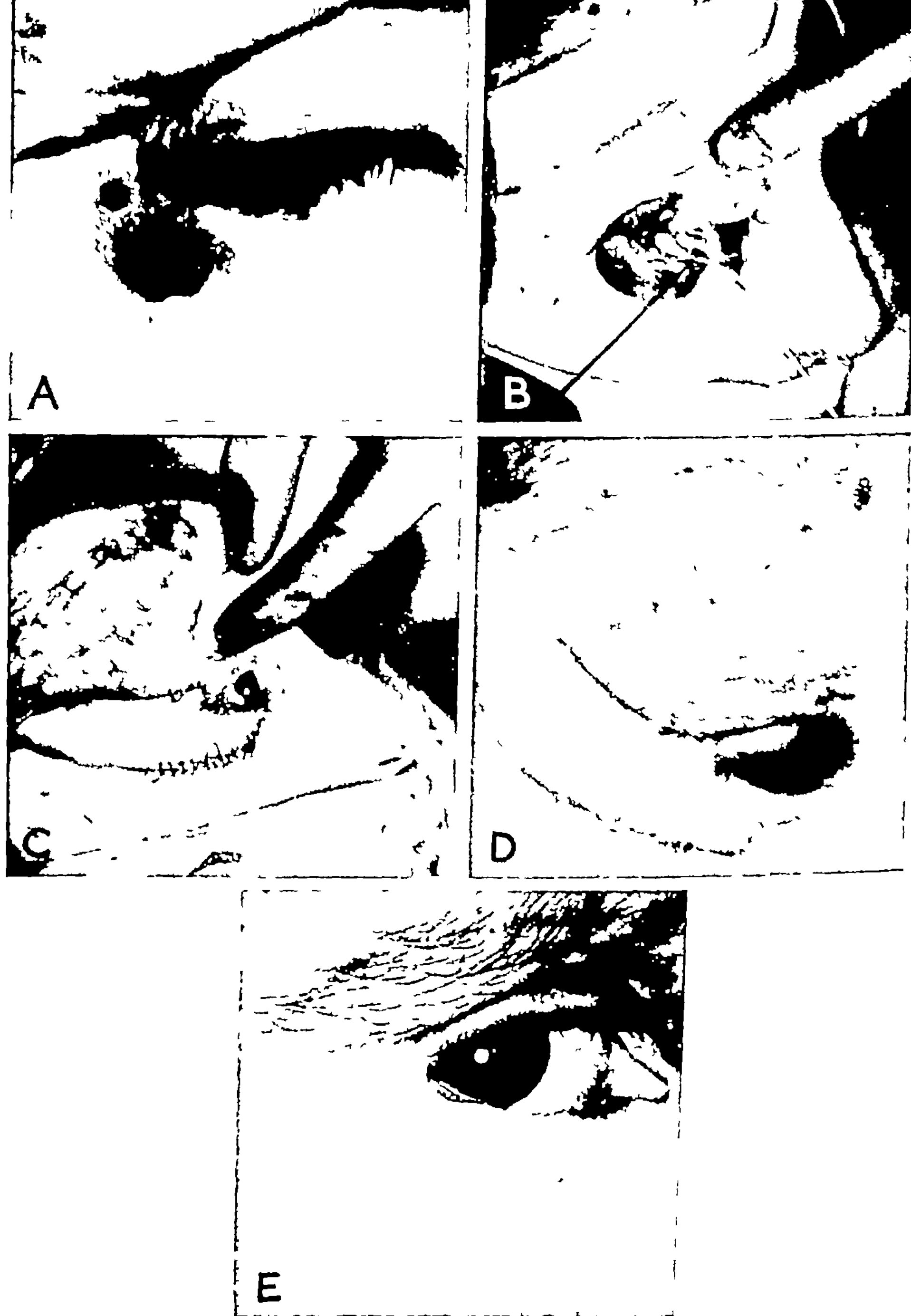


FIG 8, 7

The use of a temporal bridge pedicle to provide cover after excision of the recurrence of a rodent ulcer in the centre of a previously applied post-auricular whole skin graft

A The lesion

B The excision leaving conjunctival lining, and the temporal flap outlined

C, D The flap transferred with secondary defect split-skin grafted

E The final result after return of bridge segment of flap

The total defect (Fig 8, 9)

The method described for a partial defect can be extended to reconstruct the entire lower lid using a bipedicled bridge flap from upper eyelid or a temporal flap if the skin cover required is more in area than can readily be provided by the upper eyelid If the reconstructed eyelid is unduly lax it can be reinforced later by inserting a narrow strip of auricular cartilage but such support is seldom needed in the event

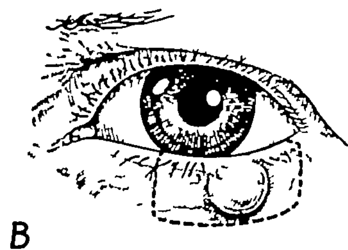
Various methods intended to add marginal eyelashes to a reconstructed eyelid have been suggested but they are not recommended The fundamental lack of conjunctiva tends to give rise to slight entropion and the added hairs at the lid margin cause trichiasis

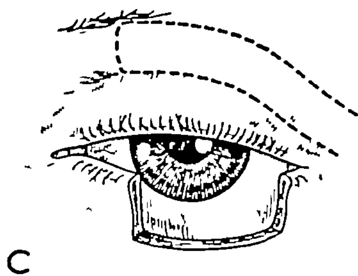
An alternative method of reconstructing an entire lower eyelid has been described in which the upper eyelid is split as far as the upper border of the tarsal plate into a superficial layer of skin and orbicularis muscle and a deep layer of tarsal plate and conjunctiva The tarso-conjunctival layer is advanced downwards and sutured to the conjunctiva mobilised from the lower fornix to give complete conjunctival lining leaving only a small opening at the medial canthus for draining the tears The raw area left by the conjunctival closure is covered with a post auricular full thickness graft a bipedicled flap from upper eyelid or a temporal based forehead flap whichever is more suited to the circumstances of the actual case When the separated layers have healed in their new relationship an incision is made through the full thickness of eyelid taking the skin margin of the intact lid as a guide for the level of section and so distributing the tarsal plate between the upper and the reconstructed lower eyelid

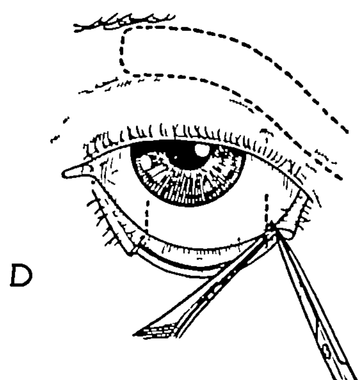
The results of this method compare unfavourably with those of the first method described and in addition it interferes with the normal upper eyelid The upper eyelid plays such an important role in normal activity of the eyelids that it must be considered undesirable to interfere with its functional integrity to its potential detriment by using any of its tissue other than skin in reconstructing a lower eyelid

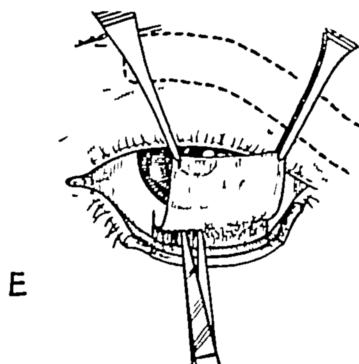
The lower eyelid on the other hand has less importance functionally and the principle of the method has its real value in reconstructing the upper eyelid at the expense of the lower as described below

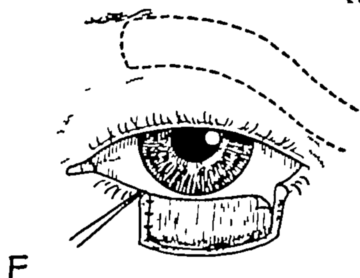














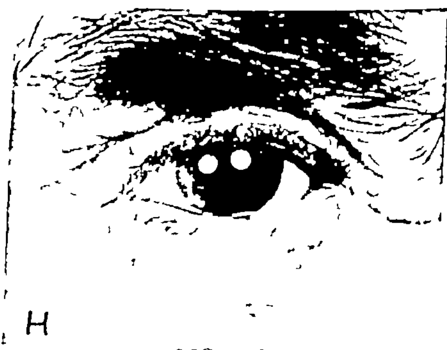


Fig. 8, 8

Partial reconstruction of lower eyelid. Rodent ulcer (A) requiring excision of full thickness of eyelid (B, C). Mobilisation of conjunctiva of lower fornix (D) and globe (E), advanced (F) to form lining of the reconstructed eyelid. Skin cover provided by a single pedicled flap of upper eyelid (G), the secondary defect closed by direct suture. The final result (H), after excision of the bridge segment of the flap.

The total defect (Fig 8, 9)

The method described for a partial defect can be extended to reconstruct the entire lower lid using a bipedicled bridge flap from upper eyelid or a temporal flap if the skin cover required is more in area than can readily be provided by the upper eyelid If the reconstructed eyelid is unduly lax it can be reinforced later by inserting a narrow strip of auricular cartilage but such support is seldom needed in the event

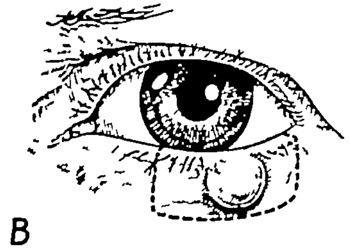
Various methods intended to add marginal eyelashes to a reconstructed eyelid have been suggested but they are not recommended The fundamental lack of conjunctiva tends to give rise to slight entropion and the added hairs at the lid margin cause trichiasis

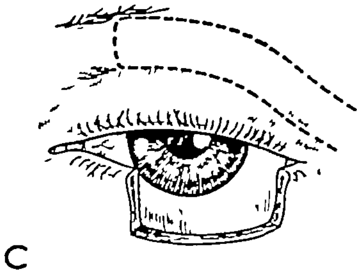
An alternative method of reconstructing an entire lower eyelid has been described in which the upper eyelid is split as far as the upper border of the tarsal plate into a superficial layer of skin and orbicularis muscle and a deep layer of tarsal plate and conjunctiva The tarso-conjunctival layer is advanced downwards and sutured to the conjunctiva mobilised from the lower fornix to give complete conjunctival lining leaving only a small opening at the medial canthus for draining the tears The raw area left by the con junctival closure is covered with a post auricular full thickness graft, a bipedicled flap from upper eyelid or a temporal based forehead flap whichever is more suited to the circumstances of the actual case When the separated layers have healed in their new relationship an incision is made through the full thickness of eyelid taking the skin margin of the intact lid as a guide for the level of section and so distributing the tarsal plate between the upper and the reconstructed lower eyelid

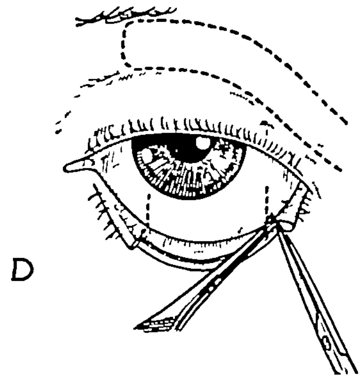
The results of this method compare unfavourably with those of the first method described and in addition it interferes with the normal upper eyelid The upper eyelid plays such an important role in normal activity of the eyelids that it must be considered undesirable to interfere with its functional integrity to its potential detriment by using any of its tissue other than skin in reconstructing a lower eyelid

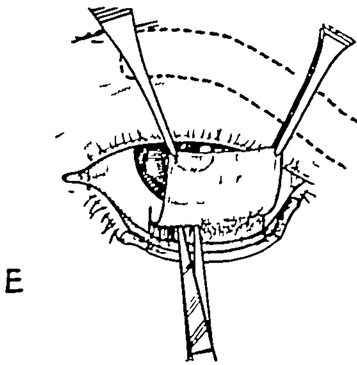
The lower eyelid on the other hand has less importance functionally and the principle of the method has its real value in reconstructing the upper eyelid at the expense of the lower as described below

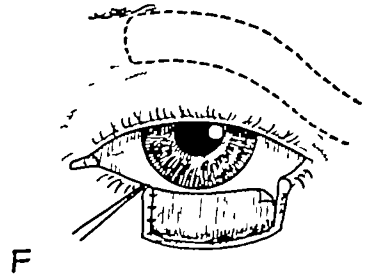














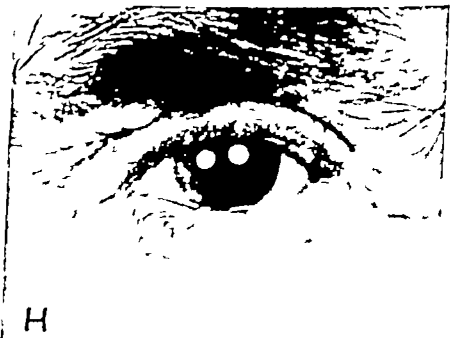


Fig. 8, 8

Partial reconstruction of lower eyelid. Rodent ulcer (A) requiring excision of full thickness of eyelid (B, C). Mobilisation of conjunctiva of lower fornix (D) and globe (E), advanced (F) to form lining of the reconstructed eyelid. Skin cover provided by a single pedicled flap of upper eyelid (G), the secondary defect closed by direct suture. The final result (H), after excision of the bridge segment of the flap.

The Upper Eyelid

It is seldom necessary to reconstruct more than the tarsal plate segment of the upper eyelid for this is the part which is usually traumatically avulsed and tumours requiring excision wider than this generally call for orbital exenteration

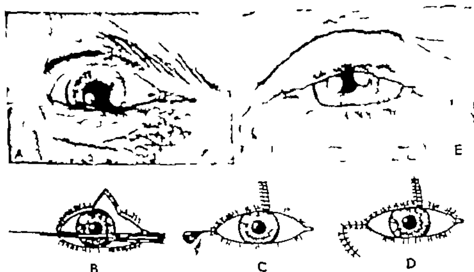
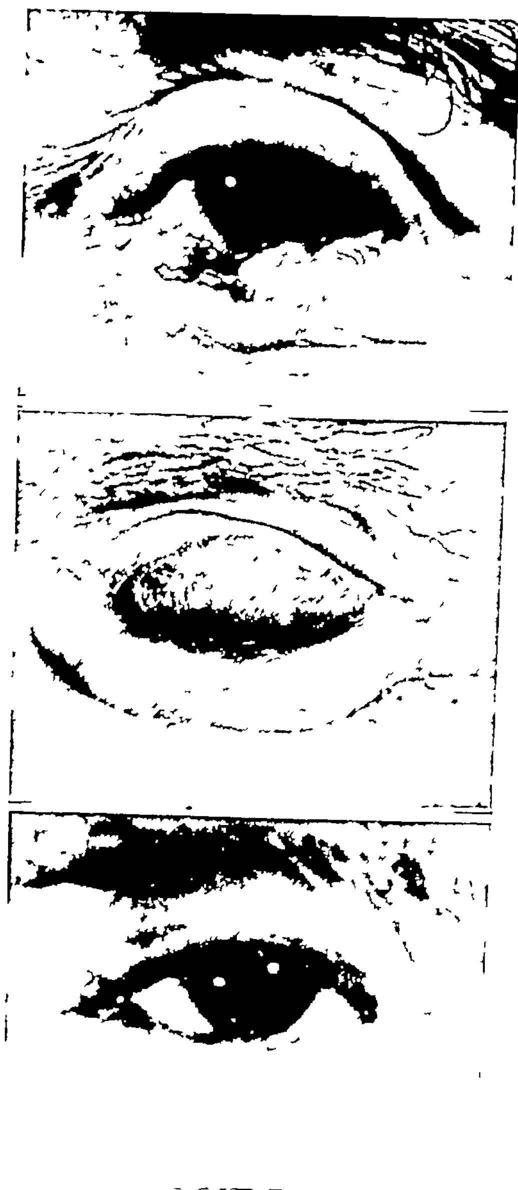


Fig 8, 10

Partial reconstruction of upper eyelid Rodent ulcer (A) of upper eyelid excised (B) Repair by lateral canthotomy with mobilisation of the lateral half of the upper eyelid dividing radically the orbicularis muscle to permit advancement of the lateral segment of the lid and closure of the post-excisional defect (C) excision of the resulting dog-ear redundancy (D) giving the final result (E)

The partial defect

When the defect does not actually include the lateral canthal region the most straightforward method of reconstruction is to carry out a lateral canthotomy dividing the upper lid segment of the lateral canthal ligament and mobilising the remaining lateral eyelid segment so that it can be advanced medially and sutured to the medial segment (Fig 8 10) The orbicularis muscle must be divided radically upwards from the lateral margin of the canthotomy incision to allow the lid segment to be advanced freely and sutured without tension This medial advancement has the effect of bringing in skin previously lateral to the line of the canthus to form the lateral segment of the reconstructed eyelid With the advancing of the skin the conjunctiva may also have to



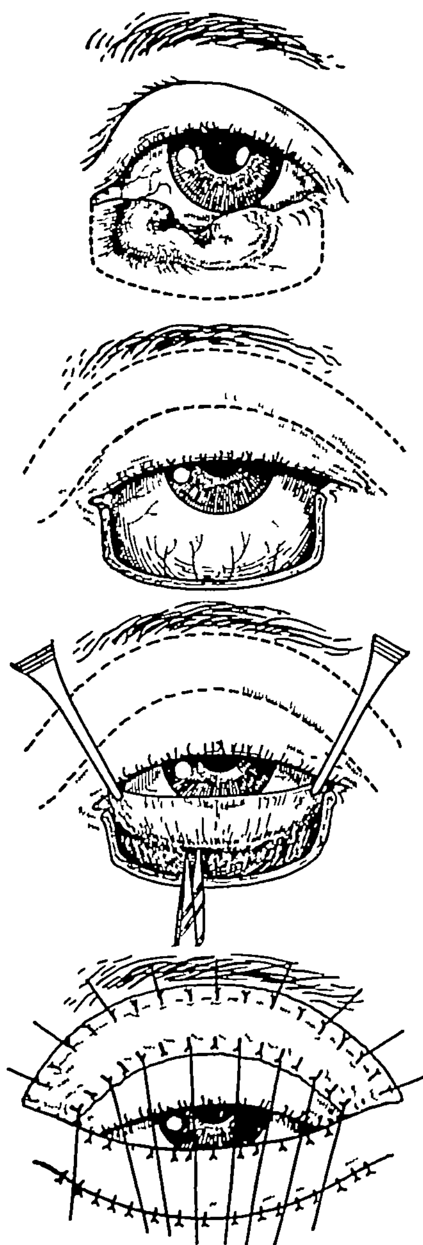


Fig. 8, 9

Reconstruction of the entire lower eyelid excised for rodent ulcer involving the whole thickness of the lid. Conjunctival lining provided by advancing the conjunctiva of the globe as far as the limbus and skin cover by bipedicled flap from the upper eyelid, secondary cover of the upper eyelid defect with a split-skin graft. On each side the bridge segment excised to give the final result.

The total defect

The principle of repair by advancing a tarso-conjunctival flap from the intact eyelid has already been mentioned and this method can be used to reconstruct the entire width of the upper lid (Fig 8, 12)

The margin of the lower eyelid is incised along the grey line and the lid is separated into a superficial musculo cutaneous and a deep tarso-conjunctival layer from just lateral to the lacrimal punctum almost to the lateral canthus From each end of the incision along the lid margin vertical incisions are made through the tarso-conjunctival flap down to the lower fornix The tarso conjunctival flap is then mobilised as far as the lower fornix and advanced upwards to allow its upper margin to be sutured with an interweaving suture to the edge of the remaining upper lid conjunctiva At this point an effort should be made to identify the edge of the levator palpebrae superioris muscle and fix it along with the conjunctiva to the upper edge of the tarsal plate If this can be successfully accomplished it helps to prevent the occurrence of ptosis which is so often an unfortunate characteristic of upper lid reconstructions

If it is available a bipedicled flap of the remaining skin of the upper eyelid is brought down to provide cover for the tarso-conjunctival flap and sutured to the margin of the lower eyelid skin The secondary defect of upper eyelid skin is free skin grafted

A bridge pedicle of forehead skin may be required if insufficient upper eyelid skin is available but such skin is unduly thick and despite maximal thinning it tends to remain rigid and immobile when the tarsorrhaphy has been divided in due course

In this way the tarsal plate is distributed between the lower and the reconstructed upper eyelids and when the separated layers have consolidated in their new positions in 2–3 months the tarsorrhaphy is divided

As already indicated the end results both cosmetically and functionally tend to be imperfect either because ptosis prevents the reconstructed lid from clearing the cornea well enough for normal vision or because the reconstructed lid is short and fails to cover the cornea adequately during sleep and the surgeon should aim to steer between these two extremes

be mobilised to move medially and provide lining, partially obliterating the lateral fornix, though enough "slack" is usually present to make mobilisation unnecessary as a formal step The advancement of the skin also creates a "dog-ear" of redundancy lateral to the lower lid, and excision of a triangle of skin is necessary

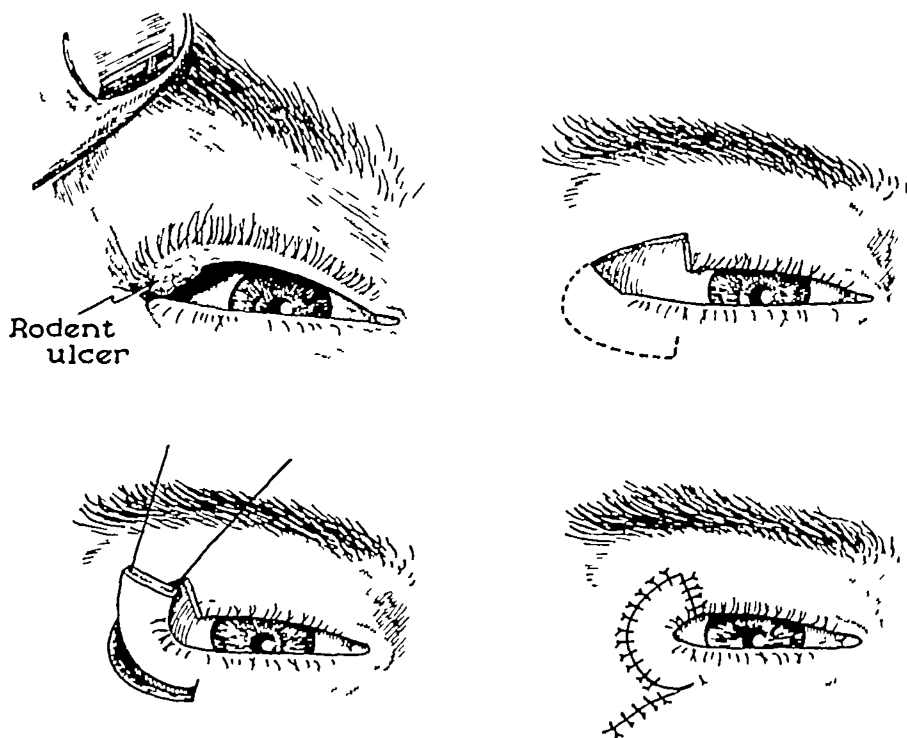


FIG 8, 11

The repair of a full-thickness defect of the lateral third of upper eyelid following excision of rodent ulcer using a "fan flap" of lower eyelid

to equate the wound lengths of the canthotomy When the two eyelid segments are sutured together careful matching at the lid margin is necessary to avoid notching and the vertical line of skin suture may with advantage be broken by a Z-plasty

A defect of the lateral third can be repaired by a procedure similar in principle to the fan flap as used in repairing a lip defect near the angle (Fig 8, 11) A "fan flap" of the lateral part of the lower lid is mobilised, dividing the lateral canthal ligament, and rotated into the defect to provide skin and lining simultaneously This has the effect of reducing the length of the palpebral fissure and although function is usually good the cosmetic result tends to be imperfect

The total defect

The principle of repair by advancing a tarso conjunctival flap from the intact eyelid has already been mentioned and this method can be used to reconstruct the entire width of the upper lid (Fig 8 12)

The margin of the lower eyelid is incised along the grey line and the lid is separated into a superficial musculo-cutaneous and a deep tarso-conjunctival layer from just lateral to the lacrimal punctum almost to the lateral canthus From each end of the incision along the lid margin vertical incisions are made through the tarso-conjunctival flap down to the lower fornix The tarso conjunctival flap is then mobilised as far as the lower fornix and advanced upwards to allow its upper margin to be sutured with an interweaving suture to the edge of the remaining upper lid conjunctiva At this point an effort should be made to identify the edge of the levator palpebrae superioris muscle and fix it along with the conjunctiva to the upper edge of the tarsal plate If this can be successfully accomplished it helps to prevent the occurrence of ptosis which is so often an unfortunate characteristic of upper lid reconstructions

If it is available a bipedicled flap of the remaining skin of the upper eyelid is brought down to provide cover for the tarso-conjunctival flap and sutured to the margin of the lower eyelid skin The secondary defect of upper eyelid skin is free skin grafted

A bridge pedicle of forehead skin may be required if insufficient upper eyelid skin is available but such skin is unduly thick and despite maximal thinning it tends to remain rigid and immobile when the tarsorrhaphy has been divided in due course

In this way the tarsal plate is distributed between the lower and the reconstructed upper eyelids and when the separated layers have consolidated in their new positions in 2–3 months the tarsorrhaphy is divided

As already indicated the end results both cosmetically and functionally tend to be imperfect either because ptosis prevents the reconstructed lid from clearing the cornea well enough for normal vision or because the reconstructed lid is short and fails to cover the cornea adequately during sleep and the surgeon should aim to steer between these two extremes

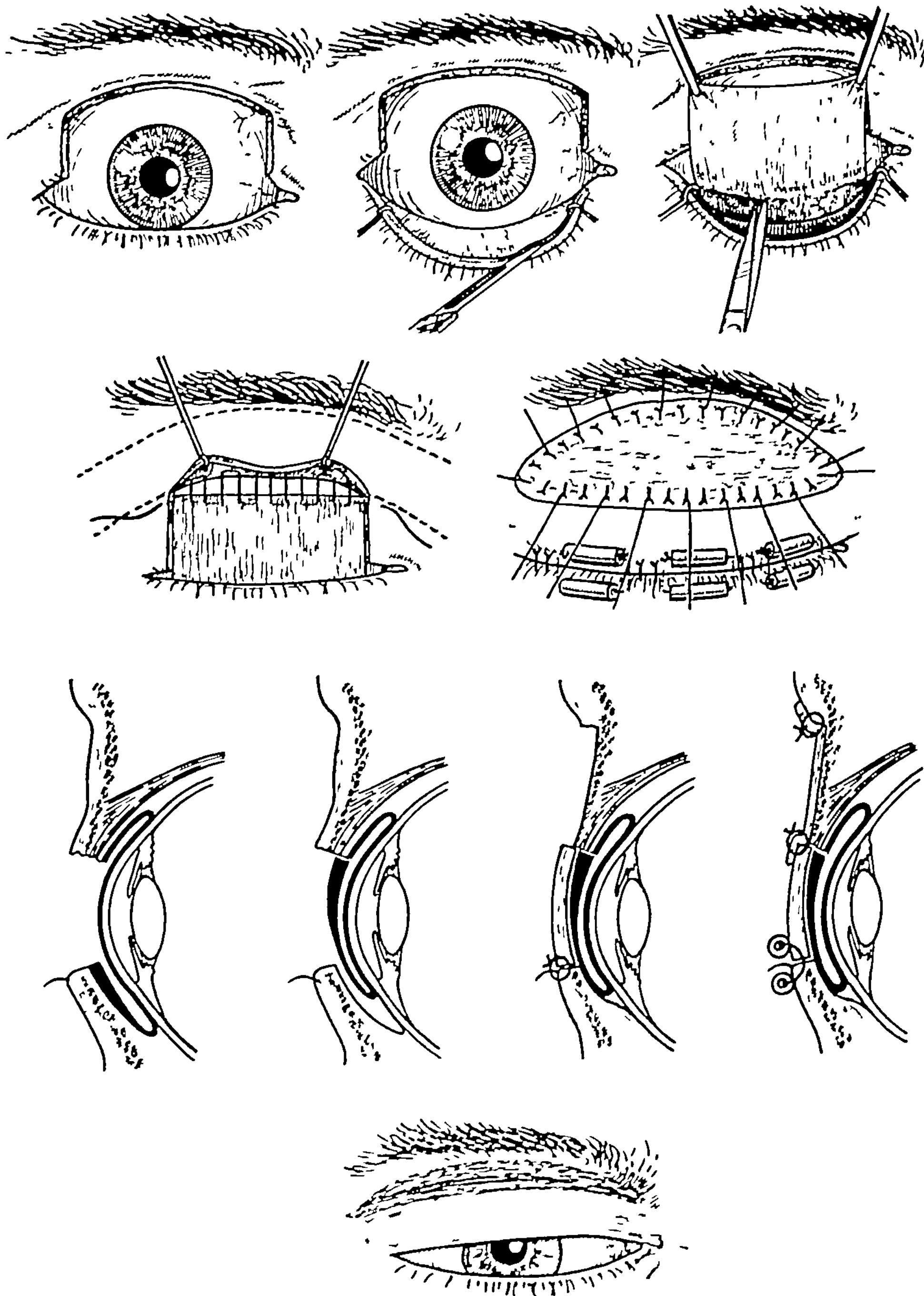


FIG. 8, 12

Total reconstruction of the upper eyelid. Incision along the grey line and separation of the lower eyelid into tarso-conjunctival and musculo-cutaneous layers. Mobilisation and advancement of the tarso-conjunctival layer for suture to the conjunctival fringe of the margin of the upper lid defect to provide conjunctival lining. Skin cover provided by advancing a bipedicled flap of the skin below the eyebrow with free skin grafting of the secondary defect. Subsequent division of the tarsorrhaphy to give the final result.

BIBLIOGRAPHY

HUGHES W L (1954) *Reconstructive Surgery of the Eyelids* 2nd Ed St Louis C. V Mosby

MANCHESTER W M (1951) A simple method for the repair of full thickness defects of the lower lid with special reference to the treatment of neoplasms *Brit J plast Surg* 3 252

SCHOFIELD A L (1954) A review of burns of the eyelids and their treatment *Brit J plast Surg* 7 67

STALLARD H B (1958) *Eye Surgery* 3rd Ed Bristol J Wright & Sons

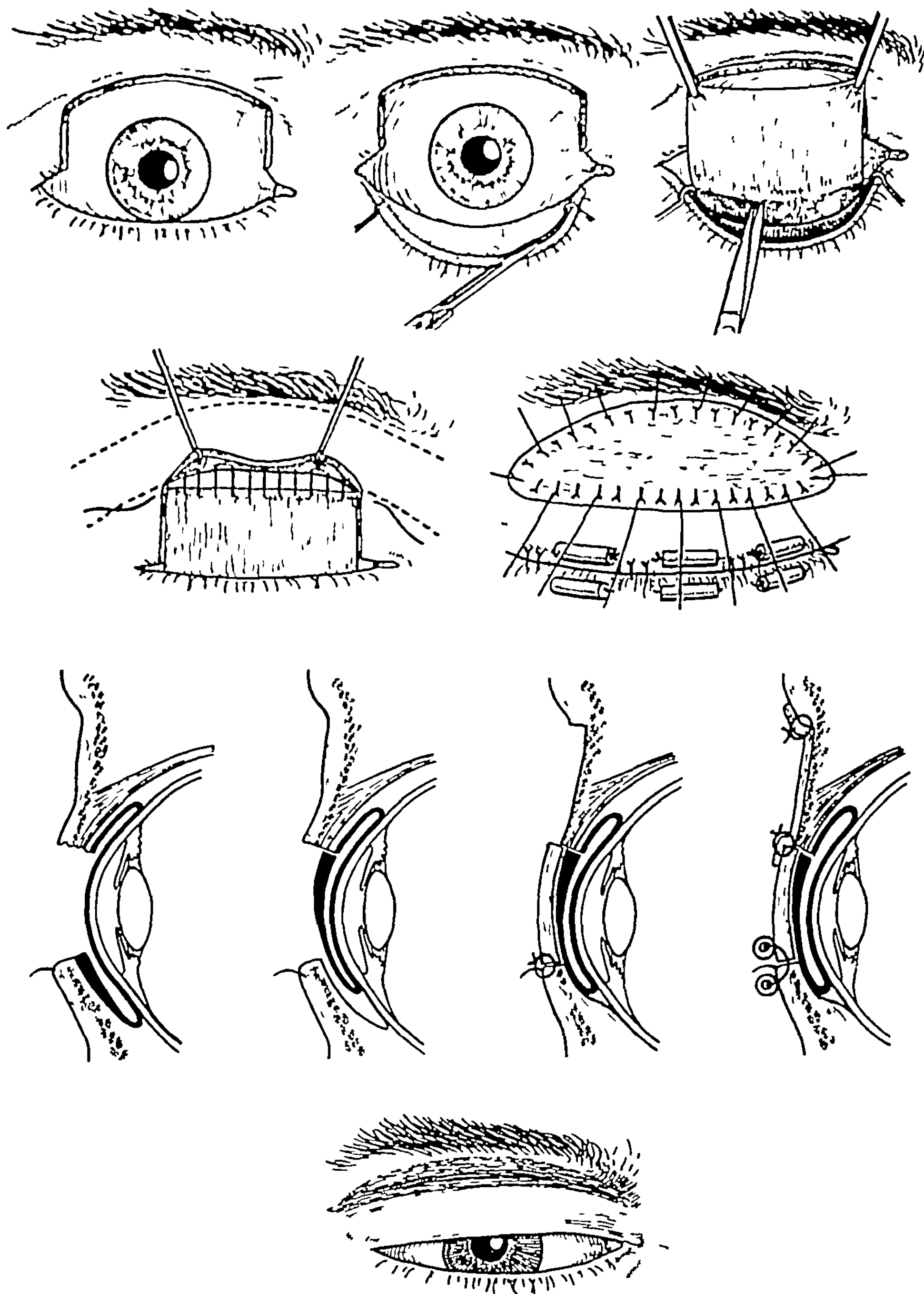


FIG 8, 12

Total reconstruction of the upper eyelid Incision along the grey line and separation of the lower eyelid into tarso-conjunctival and musculo-cutaneous layers Mobilisation and advancement of the tarso-conjunctival layer for suture to the conjunctival fringe of the margin of the upper lid defect to provide conjunctival lining Skin cover provided by advancing a bipedicled flap of the skin below the eyebrow with free skin grafting of the secondary defect Subsequent division of the "tarsorrhaphy to give the final result

INDEX

Bold type denotes illustration on pages apart from those containing the textual reference

INDEX

Bold type denotes illustrations on pages apart from those containing the textual reference

T

T